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Statements of the relative merits of the world's finest mineralogical specimens are no more than indications, but the testimony given at our Paris store during the recent International Geological Congress was of value even as an indication. The entirely new types of Crocoite lately received there were the result of seven months' work of our Collector, who had previously made several trips to Dundas. The various mines yielding the Chromate of Lead in the past eight years are now abandoned, offering but little hope for specimens in the future. The surface indications at one of these flooded mines appeared to warrant operations, and a 100 foot tunnel was driven into the hill above. After much expensive work a comparatively large quantity of fine, rich colored crystals on dark gangue were found, and a good supply of pure massive Crocoite saved.

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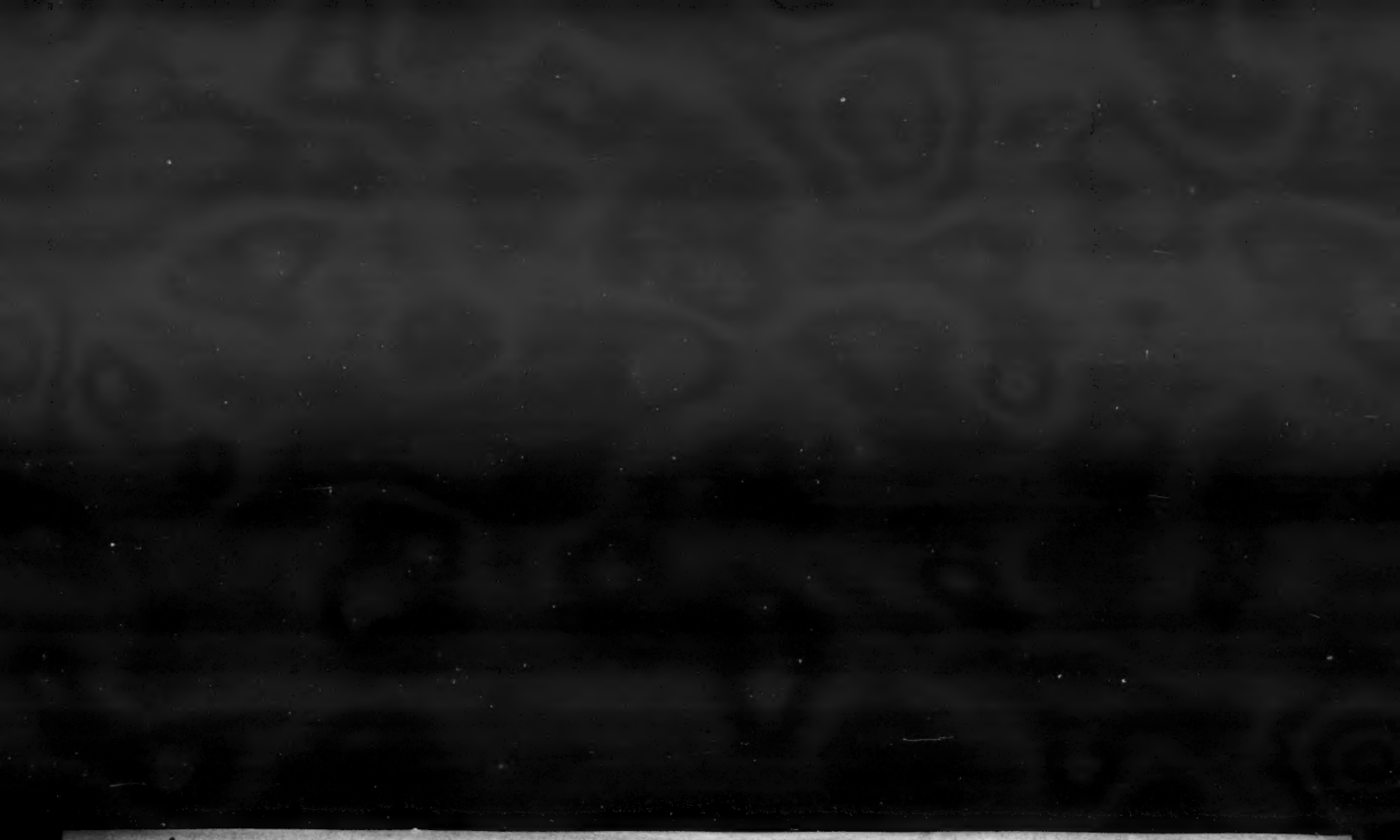
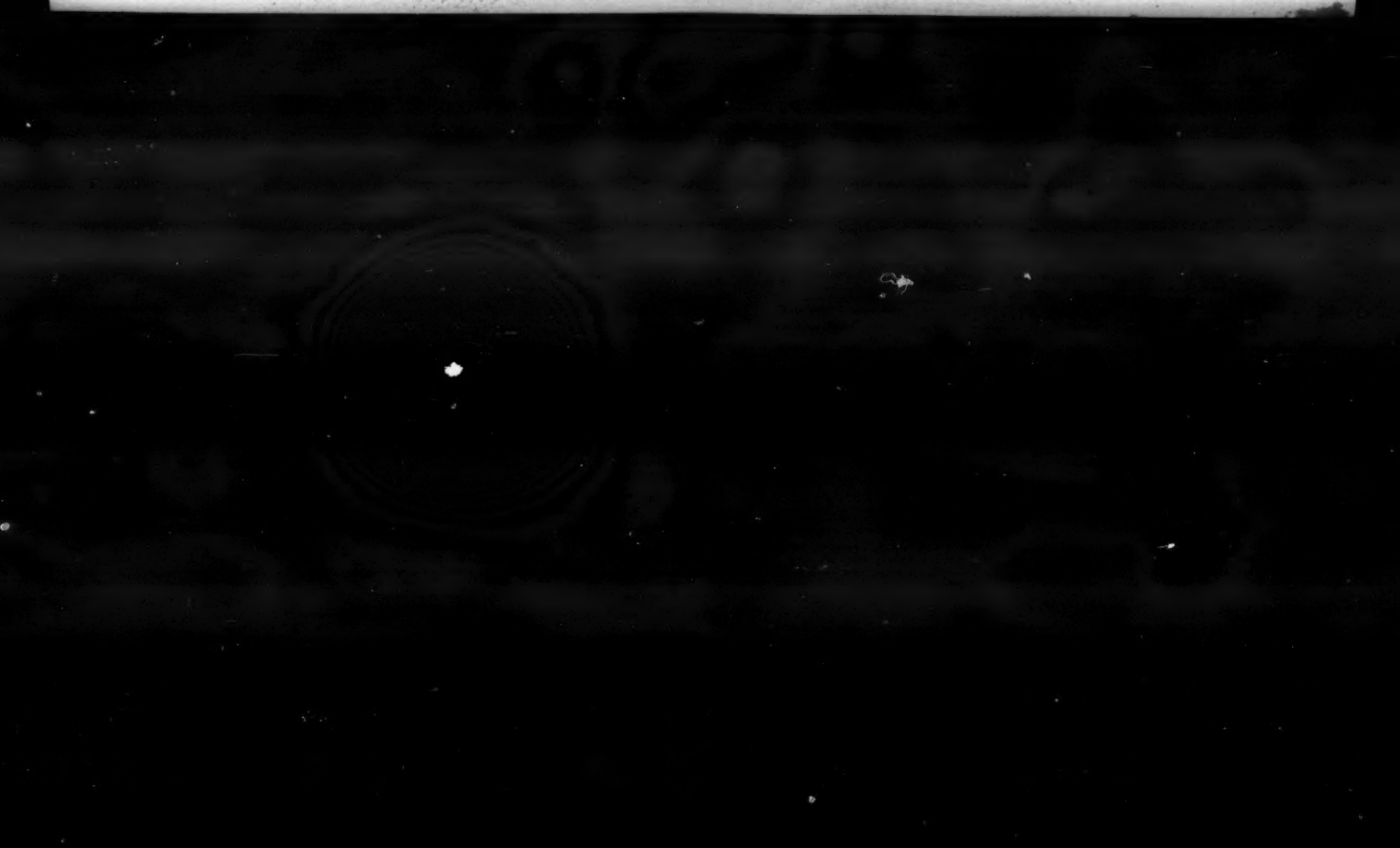




THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXV.—*Notes on the Colorado Canyon District;* by W. M. DAVIS.

A VISIT to the district of the Colorado Canyon leaves the traveler with a deepened impression of his indebtedness to the three explorers from whom an understanding of that marvelous region has come. Newberry, crossing the plateaus south of the canyon in 1858, recognized the deep erosion of the fundamental crystallines before the deposition of the Paleozoic series, and the extensive denudation of the plateau uplands where the retreating escarpments succeed each other in order of age; he made explicit statement that not only the canyon but the escarpments of the plateaus "belong to a vast system of erosion, and are wholly due to the action of water."* Powell's adventurous expedition down the river in 1869, justly classed with the most daring explorations of the continent, added an account of the division of the plateaus into huge blocks by faults and monoclines trending about north and south, in contrast to the cliffs of erosion which in a general way trend east and west; he clearly stated that "the cliffs of erosion are very irregular in direction, but somewhat constant in vertical outline; and the cliffs of displacement are somewhat regular in direction, but very inconstant in vertical outline."† Dutton's more elaborate surveys of the canyon and of the plateaus to the north of it in 1879 and 1880, aided by Holmes' wonderful drawings, have made the canyon district classic ground, the type of all that is gigantic in displacements and denudation, the region to be cited, at home and abroad, as

* Ives Expedition: Report upon the Colorado River of the West, Washington, 1861. Part III, Geological Report, 45.

† Exploration of the Colorado River of the West, Washington, 1875, 191.

the standard example, best studied, best described, and best illustrated, of river work on a grand scale.* It should be added that the topographical maps made by Bodfish and Renshawe in 1879, although of small scale and large contour interval, are of great value in giving the location and altitude of the more important features.

The wish that I have had for many years to visit the canyon was fortunately brought to fulfilment in June. Our party consisted of Prof. R. E. Dodge of Columbia University, Dr. H. E. Gregory of Yale University, Mr. R. L. Barrett of Chicago, Mr. Richard Wetherill of Pueblo Bonito, New Mex., Dr. Tempest Anderson of York, England, and the writer. Great assistance in plans and outfit was given by Mr. F. E. Hyde, Jr., of New York, who was unhappily unable to go with us. We left the Sante Fe Pacific Railroad at Flagstaff, Arizona, on June 4, and followed a very irregular route northward, partly with wagons, partly with horses and pack train, and on June 26 reached Milford, Utah, whence the Oregon Short Line carried us to Salt Lake City. Postponing a fuller account of our observations to a later date, I desire to make brief statement here of certain points on which other conclusions than those announced in the Survey reports seem to be admissible.

The unconformities in the Canyon.—The Kaibab section of the canyon discloses the nearly even floor on which the horizontal Paleozoic strata rest. The floor is of complex structure. The fundamental schists with granitic dikes, which are exposed in the western Kaibab section, are overlaid in the eastern section by the heavy Unkar and Chuar series, dipping eastward and measuring according to Walcott about two miles in thickness.† The wedge in which the tilted formations terminate westward is a most remarkable geological structure, alike for its distinctness and for its significance. It is easily recognized near the bottom of the northern cliffs of the canyon when viewed from the southern rim at Hance's or at Cameron and Berry's; these primitive stopping places being at the ends of the road from Flagstaff, which forks a few miles before reaching the rim. The wedge is still better seen by descending the Grand View trail from Cameron and Berry's to a promontory of the Red Wall limestone north of the "copper mine." The crystalline floor of the Unkar series is of extraordinary evenness; no inequalities in it were detected in the view from the Red Wall promontory, except a small pre-Paleozoic fault (see

* Tertiary History of the Grand Canyon District, with Atlas, U. S. Geol. Survey, Monogr. II, Washington, 1882.

† 14th Ann. Rept., U. S. G. S., 1894, 508–512.

diagram by Gilbert, fig. 52, in Walcott's article, above referred to). Close to the base of the Unkar is a sheet of basalt, described as a contemporaneous flow by Walcott (l. c., 516–518), but to our view seeming rather to be an intrusive sill, inasmuch as it broke from one layer to another, instead of lying conformably between the under and overlying beds.

The floor of the Paleozoic series is somewhat less regular than that of the Unkar. A few miles down the canyon there is a mound of schists that rises rather higher than the basal Tonto sandstone, and the harder layers of the lower Unkar also interrupt the Tonto for a mile or more up stream from the apex of the wedge on the northern side of the canyon. It is notable that the deformed schists beneath the Unkar series descend by a continuous and very steep slope to the river; hence their whole mass must be about equally resistant; but west of the apex of the wedge and for a number of miles down

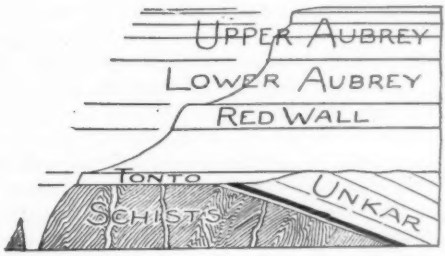


FIG. 1. Diagram to illustrate the section and profile of the canyon in the Kaibab

stream, the schists show a distinct bench just beneath the Tonto before steepening to their precipitous lower slope; hence here the upper part of the schists must be weaker than the lower. It occurred to me that this weakness may be ascribed to a pre-Tonto subærial weathering of the schists. If so, the gently undulating sub-Tonto floor may be, with renewed confidence, regarded as an ancient lowland of subærial denudation, as described by Powell, only slightly modified by marine erosion previous to Tonto deposition; while the sub-Unkar floor may have been planed down by the sea to smooth and firm rock from some unknown but probably moderate measure of relief, before the Unkar series was laid down on it.

The erosion of the plateaus.—The retreating cliffs of Permian, Triassic and other formations, on the north and east of the Grand Canyon district, have been taken to prove extensive erosion over the plateaus in which the canyon has been cut. Dutton concludes that this erosion was accomplished during a

lower stand of the region; in other words, that the plateaus are parts of a vast peneplain produced in a cycle of erosion anterior to that in which the canyon has been eroded, the two cycles being separated by an uplift of several thousand feet. It has been pointed out by other observers (although I believe that no statement of their opinion has been published) that the supposed peneplain surface coincides roughly with the resistant Upper Carboniferous strata over large areas, and hence that the plateaus might be explained as a surface of halting or at least of hesitating erosion in a single cycle, after the stripping of the weaker overlying formations. It is not easy to make definite choice between these two explanations, but I believe Dutton's to be the more probable of the two, for such reasons as the following. There is a mesa in the valley of the Little Colorado, southeast of the road from Flagstaff to Tuba, capped by a horizontal sheet of lava which rests unconformably on a bevelled surface of tilted Permian shales; but the shales are elsewhere denuded to a lower level. Again, there are numerous and extensive landslides at the base of the Echo and Vermilion (Triassic) cliffs south and west of Lee's Ferry; the slides seem to indicate a revival of sapping after a long pause. Further, the considerable length of many streams that flow against the dip of the strata suggests the need of the most favorable conditions for their development, such as would be associated with two cycles of erosion rather than with only one. Finally, the strong contrast between the gigantic young ravines of the steep canyon walls and the shallow mature valleys of the plateaus seems beyond explanation as dependent on the resistance of the Upper Carboniferous strata during a single cycle of erosion. But much more work should be done before this question can be definitely settled.

The Esplanade.—The canyon, where traversing the Uinkaret plateau and the greater part of the adjacent Kanab, consists of a broad and flat-floored upper valley, beneath which a deep and narrow chasm has been cut. Dutton terms these two parts the upper (or outer) and the inner canyons, and gives the name, esplanade, to the well developed floor of the upper canyon. He explains the esplanade as the result of valley-broadening during a pause in the general uplift in consequence of which the plateaus have been dissected: in other words, after a first cycle in which the plateaus were broadly denuded, a second cycle was introduced by general uplift of the region; but this uplift was interrupted by a pause long enough for the erosion of the upper canyon (l. c., 121). Other observers have suggested that the esplanade is a structural bench determined by the resistance of the Red Wall limestone, from which the overlying weak lower Aubrey sandstones and shales have been stripped. Cer-

tainly the surface of the esplanade, as seen in the magnificent prospect from Vulcan's Throne, where the canyon cuts the Toroweap valley, coincides closely with the top of the Red Wall series. Further up the canyon, the topographical maps show the esplanade in Kanab canyon on the north and in Cataract canyon on the south, but its distinctness lessens eastward and it disappears before entering the Kaibab. Where we saw the canyon in the Kaibab, its cross section was altogether different from that where the esplanade is well developed in the western Kanab. In the Kaibab there are two structural benches, as shown in fig. 1: one is determined by the Red Wall limestone, the other by the Tonto sandstone; and of the two the latter is rather more pronounced than the former. The change in form from the Uinkaret to the Kaibab seems to result from a weakening of the strata that are included between the firm limestones of the Red Wall and the firm sandstones of the Tonto. This change in structure is fully recognized by Dutton, and he explains the difference of form between the Uinkaret and the Kaibab sections by the greater altitude of the Kaibab during the erosion of the canyon (l. c., 257, 258). He does not, however, explain the absence in the Kaibab section of all signs of the pause during the general uplift by which he explained the esplanade further west. To my view, the esplanade, like the Kaibab benches, seemed to be entirely of structural origin; it does not seem to be necessary to postulate a pause during uplift in order to account for it.

The Toroweap is a broad valley that has been eroded along the fault that divides the Kanab and the Uinkaret plateaus, north of the canyon. A similar valley, which I have designated in my notes as the South Toroweap, is seen on the southern side of the canyon. Both of these valleys are flat-floored and open on the canyon close to the level of the esplanade. Dutton concluded that the Toroweap is the broadened valley of an ancient river which disappeared by reason of change from humid to arid climate before the inner canyon was cut. He recognizes that the valley has been somewhat shallowed by lava flows from the volcanoes of the Uinkaret on the west, but does not attach much importance to this fact (l. c., 92, 99). It does not seem necessary to adopt Dutton's conclusion as to climatic change, for the lavas in the floor of the Toroweap appeared to be in sufficient volume to account for its shallowness in contrast to the depth of Kanab and Cataract canyons a little further east.

Date of faulting.—The displacements by faults and monoclines, resulting in the division of the plateau region into a number of huge blocks, Shiwits, Uinkaret, Kanab, Kaibab, etc., have been variously dated by different observers. Powell

states that when the great denudation began, there were no faults and no benches; the first uplift was broad and even, without differential displacements; the displacements began later, and so slowly as not to affect the course of the original streams (l. c., 200, 201). Dutton dates the Hurricane fault as later than the earlier lava flows and earlier than the later ones (hence later than the great denudation and before the later canyon cutting); the Toroweap fault was not begun until the upper canyon had attained very nearly its present form, so that the floor of the esplanade as a topographic feature was dislocated by the fault; the Kaibab began to have a distinct existence only after the great Miocene denudation, when the Colorado was beginning the erosion of the upper canyon; the Echo cliffs monocline is rated as very nearly coeval with the East Kaibab monocline, and the latter began with the Pliocene (l. c., 117, 94, 192, 205). Walcott places the uplift of the Kaibab before the completion of the great (Miocene) denudation,* while there were still some heavy overlying strata upon it, because the layers of the monoclines are flexed without manifest fractures. The dating of the displacements therefore still offers an interesting subject for discussion.

While subordinate movements on the fault lines and monoclines may have occurred during the erosion of the inner canyon, the chief movements seem to be much older. This conclusion is enforced by several observations. First, there is the arrangement of the Permian and Triassic escarpments with respect to the northern extension of the fault lines: had the faults been of recent date, later than the great denudation by which the escarpments were pushed back for scores of miles from the original extension of their strata, the borders of the several formations as shown on a map ought not to be significantly out of line on the two sides of a displacement; for in the post-displacement period there would not have been time for much retreat of the cliffs on one side of a fault in excess of the retreat on the other side. But as a matter of fact, the Permian and Triassic cliff-makers have been greatly denuded with respect to and subsequent to the displacement of the blocked plateaus. The Permian cliffs retreat northward as they approach the Hurricane fault south of Toquerville; the Permian and the Triassic cliffs are out of line by several miles on the two sides of the fault that passes near Pipe Spring, west of Kanab. This style of arrangement was recognized by Powell, who stated that the higher blocks have been more eroded than the lower ones, and hence "the cliffs of the higher blocks stand further back from the axis of upheaval than those of the

* Bull. Geol. Soc. Amer., i, 1890, 60, 64.

lower blocks" (l. c., 191). Secondly, the Vermilion cliffs of the Trias make a great detour around the northern end of the Kaibab arch, such as could not be accounted for if the uplift of the Kaibab were as recent as the erosion of the canyon. Thirdly, the Trias margin along the Echo cliffs is in close accordance with the monocline of the same name; this proves that time enough must have elapsed since the bending of the monocline for the Triassic sandstones to retreat from whatever irregular front they may have had while they still lay horizontal, to their present well-defined structural alignment. The time that sufficed for the erosion of the canyon by the active Colorado does not seem long enough for the recession of the Triassic cliffs from an irregular to a regular front under the attack of dry-climate weather alone. Fourthly, the relatively small retreat of the Aubrey cliffs from the fault lines, as along the Hurricane and the Toroweap faults, may be explained by the relatively recent uncovering of these structures, long ago faulted.

The origin of the drainage system.—Both Powell and Dutton attribute an antecedent origin to the larger members of the drainage system in the plateau region. It is possible to conceive of the conditions necessary for the maintenance of such a drainage system through all the movements of upheaval and displacement that the plateau region has suffered; but it seems to me doubtful if these necessary conditions have been actually provided; and it is very difficult to find decisive proofs of an antecedent origin. During the great denudation by which thousands of feet of Mesozoic strata were stripped from the plateaus, there must have been opportunity for many spontaneous rearrangements of river courses. This opportunity would have been increased if there had been several successive cycles or partial cycles of denudation, separated by movements of elevation, as is entirely possible: the opportunity would have been still further increased if, as is eminently probable, displacements with slight tilting occurred during the denudation, for, as Hayes has shown, the greater rearrangements of drainage are dependent rather on gentle tilting movements of elevation than on inequality of rock resistance. The denudation of the region is usually dated as beginning in early Eocene time, because it is postulated that late Eocene strata once stretched all over the canyon district; but if a true-scale section be drawn, it does not appear improbable that the cañon district may have been slightly uplifted so as to undergo some denudation while the Eocene deposits were accumulating in basins on the north and east. The whole stretch of Tertiary time, with repeated uplifts and displacements, would

certainly offer abundant opportunity for the development of new stream courses, even if the drainage of the region had been chiefly antecedent at the beginning. Moreover, some of the valleys actually follow the strike of weak monoclinal structures, and are therefore to be explained as of subsequent rather than as of antecedent or consequent origin; other valleys slope against the dip of the strata, and may come to be classed as obsequent instead of antecedent. Altogether, this problem is so complicated that its solution seems out of reach at present. The main trunk of the Colorado may be antecedent, but such an origin seems improbable for the side streams.

Climatic changes.—The change from a moist Miocene climate to an arid Pliocene climate, already referred to in connection with the Toroweap valley, does not seem to be essential to the development of existing forms. House Rock valley, for example, is explained by Dutton as having been eroded by a member of the original antecedent drainage system, whose waters dried up at the time of the change from the moist Miocene to the dry Pliocene period; but may this valley not be equally well explained by headward erosion under a persistently dry climate along the weak Permian monoclinal strata that lie between the resistant Carboniferous strata of the Kaibab arch on the west and the heavy Triassic sandstones of the Paria plateau on the east? The valley seems to belong to the class of subsequent valleys above referred to; the depth of its floor having been determined by the sill of resistant Carboniferous strata in the platform of the Marble canyon on the southeast. The valley is not yet significantly deepened in response to the uplift which has permitted the erosion of the main canyon by the full-bodied Colorado.

The ravines which dissect the flanks of the Kaibab and the uplands of the Paria plateaus are ascribed by Dutton to the increased rainfall of the Glacial period, by which the aridity of Pliocene time was interrupted (l. c., 196, 202, 228); but in view of the active although intermittent erosion and transportation now going on in at least some of the flanking ravines of the Kaibab, it seems inadvisable to limit the origin of ravines of this class to any special period of time. Effective work is done on them to-day when thunderstorm torrents flush their channels, and similar work has probably been done ever since the uplands were stripped of the weak overlying Permian strata and exposed to erosion.

It may be added that the longitudinal summit valley of the Kaibab, classed by Dutton with House Rock and Toroweap valleys as the work of Miocene streams that became extinct with the coming of a dry Pliocene climate (l. c., 193–195),

seems explicable as a result of underground drainage. Sink holes of various sizes are found on the Kaibab uplands, and Dutton reports that large springs issue from the walls of the Kaibab canyon (l. c., 138, 196).

It was impressed upon me throughout our excursion over the plateaus that a multitude of problems connected with the history of the canyon district await solution. The earlier explorers gathered a great harvest there, and presented their results so vividly that newcomers may enter the region as if already acquainted with it. But the gleanings that the earlier explorers left are abundant; local structural studies as well as such considerations as are involved in dates of faulting, origin of stream courses, cycles of erosion and past climatic conditions, offer plentiful material to investigators for years to come.

Harvard University, July, 1900.

ART. XXVI.—*On the Determination of Minerals in thin Rock-sections by their maximum Birefringence;* by L. V. PIRSSON and H. H. ROBINSON.

IN the determination of minerals in thin sections of rocks, the common species possess certain diagnostic characters by which they are as a rule readily recognized. In doubly refracting minerals the interference colors or the birefringence between crossed nicols is probably the most generally useful character for diagnosis and this combined with the refractive index is sufficient in many cases to determine the mineral at a glance, when taken in connection with its color, cleavage, etc.

In the case of the less common or rare minerals, the approximate determination of the maximum birefringence becomes in many cases of the highest importance and in combination with other characters may be sufficient to definitely determine the species.

It is thus a matter of the greatest value to the beginner in microscopical petrography that he should learn the values of the maximum birefringence exhibited by the common minerals and associate these in his mind with the colors exhibited between crossed nicols. To do this he should have a simple and relatively accurate method. The more experienced petrographer has of course learned these relations for the common minerals by practice, though generally without any definite method.

In the case of birefringent minerals the strength of the interference colors shown by sections between crossed nicols depends on three conditions: (1) on the orientation of the section with regard to the ellipsoid of elasticity, (2) the thickness of the plate and (3) the difference in values between the axes of greatest and of least elasticity.

If the axial ellipsoid be cut perpendicular to an optic axis, and this in uniaxial crystals is of course a basal section, the section of the ellipsoid has the form of a circle. Hence for parallel light the elasticities are alike in all directions, the plate is isotropic and shows no interference-colors between crossed nicols. As soon, however, as the ellipsoidal cross-section is inclined to this position it takes an elliptical form, the light elasticities are not alike in all directions and hence interference colors are shown between crossed nicols. As the cross-section is inclined more and more the eccentricity of its elliptical form continually increases and with it the strength of the interference colors until the maximum of both is reached; in uniaxial crystals this is in the direction of the prismatic zone parallel to

the vertical axis and in biaxial crystals in a direction parallel to the plane of the axes of greatest and least elasticities, that is to say the plane of the optic axes. In these cases the difference between the indices of the axes of greatest and of least elasticity is the maximum birefringence, since it indicates the maximum eccentricity that can be obtained in any elliptical section of the ellipsoid of elasticity; for this, therefore, the strongest interference colors are shown. We have prepared a table of the values of maximum birefringence which is given on page 264. These values, which have been carefully collated from the best and most recent determinations, are given in descending order and the list embraces the great majority of rock-forming minerals.

The recognition of sections of a mineral in a rock slide which exhibit the maximum birefringence is somewhat inadequately treated in most handbooks, it being generally assumed that the student will form his own method from the optical data given. It involves the determination of the "order" of the interference color displayed. It rarely happens that the bounding walls of a mineral section in the slide are exactly perpendicular to the plane of the object and cover glasses; on the contrary they are apt to be inclined or in many cases have the form of a thin wedge. From the thin edge of such a wedge, especially by the aid of a high power and where the colors are not interfered with by the overlapping of some other mineral, as at the edge of the section, or near a crack or hole, or against some isotropic mineral or one cut nearly normal to an optic axis, it is often possible to count the successive colors in ascending order, finally arriving at the top and noting the color given by the full thickness of the section. This is essentially the same process as moving up the thickening quartz wedge and noting the colors it yields. If the ascending slope to the top of the section is extremely steep the stronger colors of the first order may be so crowded as to appear almost like a dark line. If by any chance this process cannot be used, then the section must be brought to extinction by the quartz wedge, the section then removed and the color in the wedge noted and its order ascertained by slowly withdrawing the wedge and noting the successive orders of colors down to zero.

The colors also vary with the thickness of the section. Good sections as made to-day should not vary sensibly in thickness in different portions, that is the two surfaces should be parallel. They should also average about 0·03^{mm} or 0·001 inch in thickness, or the maximum color exhibited by quartz should not be above clear white or at most pale straw-yellow.

With this thickness for the slide the majority of rock-making minerals show maximum colors in the first and second orders, colors easily remembered and determined.

In a rock slide containing a number of sections of the same mineral, the ellipsoid of elasticity will be cut in various directions and some of them must approach the maximum of birefringence, the probability increasing with the number of the sections. While it will rarely happen that one is thus oriented exactly parallel to the axial plane or optic axis, sensible divergences may exist without perceptibly altering the birefringence or vitiating the method to be presently described. In a number of haphazard sections of a mineral then, the one showing the maximum of birefringence may be assumed to be nearly parallel to the optic plane or axis thus giving approximately the highest birefringence of the mineral. This determination may be confirmed by the fact that such sections should not yield any loci of optic axes or axial bars or bisectrices in convergent light. The color in plain light, the pleochroism with one nicol, the cleavage and crystal form often help, in addition, to confirm the orientation.

If now we consider only those sections of minerals which give the maximum of birefringence, we may eliminate the factor of the orientation of the section in considering the strength of the interference colors and this will then depend on the other two factors, the thickness of the plate and the value of birefringence. There is thus a constant relation between them and if we know the thickness of the plate and the value of the maximum birefringence, we may readily calculate the interference color; or, given the thickness and the color, the maximum birefringence may be found; or, finally, with this and the color, the thickness of the plate.

These relations have been put into graphic form by Michel-Lévy in the beautiful colored plate in "Les Minéraux des roches" by Michel-Lévy and Lacroix. We have not found them expressed in graphic form in any other handbook with which we are acquainted.* The advantage of having these relations shown in a diagram where they can be readily seen, followed and used is very great. It is probable that the uncertainty, difficulty and cost of the colored plate may also have deterred some authors from using it. It is, however, by no means necessary that the plate should be colored, the diagram is the essential part and this we have thought would be of service to petrographers and students in this country, many of whom are unacquainted with the colored plate of Michel-Lévy, or are deterred from using it by its cost and inconvenient form. We have put it into compact shape and have simplified the color-names, by indicating the place of the distinct and well-

* Such as Rosenbusch, Rosenbusch–Iddings, Zirkel, Luquer or Harker. The last named, however, gives some very useful practical hints in this direction.

known colors rather than the transition tones. If anything is sacrificed to accuracy by this method, it is more than compensated for by simplicity and convenience in use.

In using this diagram (p. 265) for the determination of an unknown mineral, the thickness of the rock-section is first determined. This is done by taking some well-known mineral, such as quartz, for instance, which furnishes a number of sections in the slide and observing the highest color given by any of them. The maximum birefringence for quartz is 0·009 as seen in the table and by following this line down toward the left-hand lower corner until it intersects the vertical line of the highest interference-color observed, and by then following out to the edge on a horizontal line the thickness of the section can be told. The numbers represent hundredths of millimeters.

For the determination of an unknown mineral the highest color given in numerous sections is observed and the thickness having been determined as above, by means of the diagonals the numerical value is noted which corresponds to the given color in a section of the determined thickness. The maximum birefringence of the unknown mineral having been determined the table of birefringences is referred to and the mineral usually found to be one of a group of several having approximately the same values. Which particular one it may be, is in the vast majority of cases readily told by its comparative refractive index in plain light, cleavage, color and other optical properties.

Thus, for example, in a slide having numerous quartz sections the highest color shown is a pale yellow. The birefringence of quartz is 0·009. The diagonal 0·009 crosses the line of pale yellow at about 0·035 which gives the thickness of the section. In the slide are numerous grains of an unknown mineral, colorless, of strong refraction and whose highest color, given by several of them, is an orange-red of the second order. But there passes through the intersection of the thickness 0·035 and the line of orange-red of the second order the diagonal 0·029 which is the approximate value of the birefringence of the mineral. Referring to the table this is found to approximate to that of allanite, chondrodite, diopside cancrinite and tremolite. The refraction, color, cleavage, etc., show at once that of these, diopside is the only one which corresponds and thus the mineral is determined.

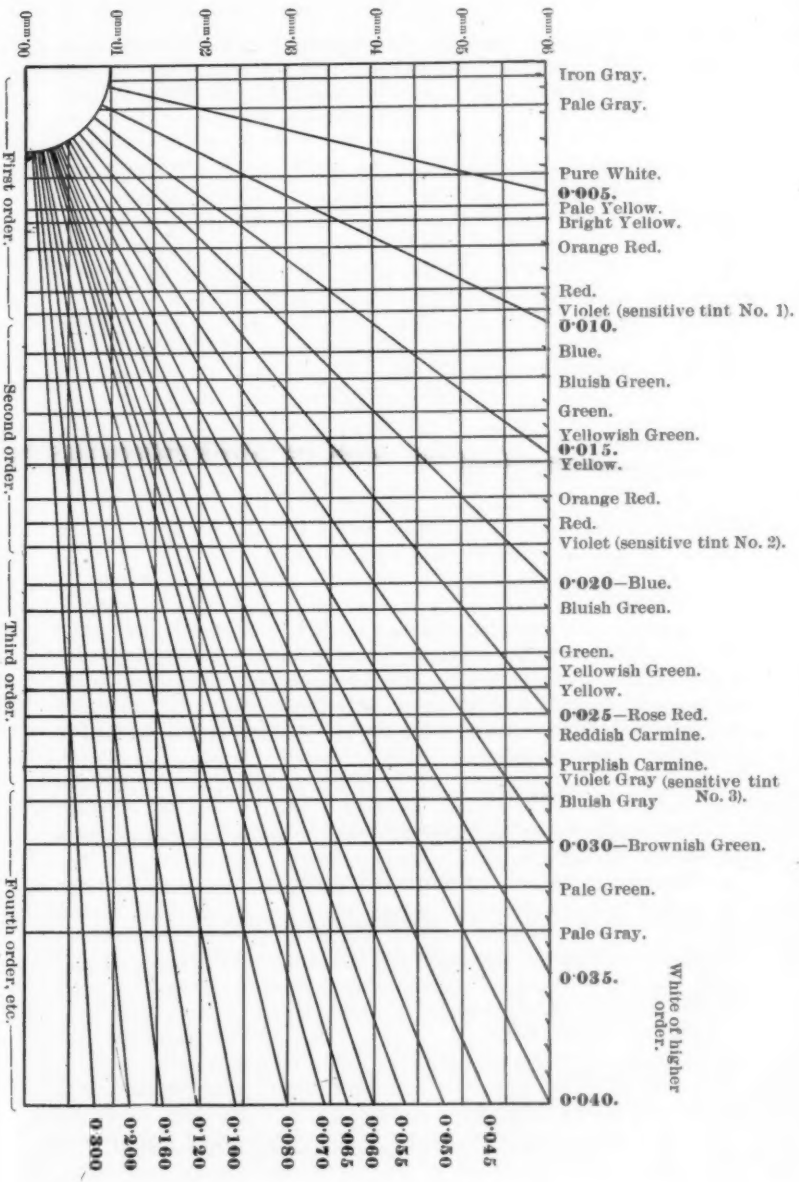
Sheffield Petrographical Laboratory,
Yale University, New Haven, Conn., April, 1900.

Birefringences (maximum).

0·287	Rutile.	0·028	Tremolite.	0·011	Clinochlore.
0·179	Dolomite.	0·025	Actinolite.	0·010	Dumortierite.
0·172	Calcite.	0·024	Anthrophyllite.	0.010	Staurolite.
0·126	Aragonite.	0·024	Diallage.	0·010	Topaz.
0·121	Titanite.	0·024	Hornblende, common.	0·009	Bronzite.
0·107	Cassiterite.			0·009	Labradorite.
0·072	Hornblende, basaltic.	0·023	Gibbsite.	0·009	Quartz.
		0·023	Tourmaline.	0·008	Albite.
0·062	Zircon.	0·022	Glaucophane.	0·008	Andesine.
0·061	Anatase.	0·021	Augite.	0·008	Cordierite.
0·058 ?	Biotite, black.	0·021	Barkevikite.	0·008	Corundum.
0·055	Epidote, dark.	0·021	Brucite.	0 008	Kaolin.
0·055	Astrophyllite.	0·021	Sillimanite.	0·008	Oligoclase.
0·050	Talc.	0·019	Pargasite.	0·007	Soda-orthoclase.
0·049	Aegirite.	0·018 ?	Tridymite.	0·007	Soda-microcline.
0·045	Monazite.	0·016	Cyanite.	0·006	Orthoclase.
0·043	Anhydrite.	0·015	Dipyre.	0·006	Microcline.
0·038	Muscovite.	0·015	Ottrelite.	0·005	Eudialyte.
0·037	Epidote, light.	0·014	Wollastonite.	0·005	Melilite.
0·036	Meionite.	0·013	Hypersthene.	0·005	Nephelite.
0·036	Olivine.	0·013	Serpentine.	0·005	Zoisite.
0·035	Biotite, light green.	0·012	Anorthite.	0·004	Apatite.
0·032	Allanite.	0·012	Natrolite.	0·002	Leucite.
0·032	Chondrodite.	0·012	Seybertite.	0·002	Vesuvianite.
0·029	Diopside.	0·011	Andalusite.	0·001	Chlorite.
0·028	Cancrinite.	0·011	Antigorite.		

Indices of Refraction (mean).

2·711	Rutile.	1·669	Bronzite.	1·566	Brucite.
2·534	Anatase.	1·667	Sillimanite.	1·56	Biotite, light green.
2·53	Brookite.	1·654	Seybertite.		
2·38	Perofskite.	1·65	Dumortierite.	1·559	Labradorite.
2·029	Cassiterite.	1·645	Apatite.	1·553	Andesine.
1·952	Zircon.	1·644	Glaucophane.	1·551	Quartz.
1·930	Titanite.	1·644	Anthophyllite.	1·551	Talc.
1·812	Pyrope.	1·641	Hornblende, common.	1·55	Dipyre.
1·811	Monazite.			1·545	Nephelite.
1·791	Aegirite.	1·638	Andalusite.	1·542	Oligoclase
1·78+	Allanite.	1·635	Tourmaline.	1·542	Gibbsite.
1·770	Almandine.	1·633	Aragonite.	1·541	Cordierite.
1·765	Corundum.	1·632	Melilite.	1·54	Serpentine.
1·751	Epidote.	1·627	Actinolite.	1·54	Kaolin.
1·747	Grossular.	1·626	Wollastonite.	1·54+	Canada balsam.
1·741	Staurolite.	1·624	Pargasite.	1·535	Albite.
1.721	Vesuvianite.	1·622	Tremolite.	1·526	Microcline.
1·721	Augite.	1·622	Dolomite.	1·523	Orthoclase.
1·720	Cyanite.	1·622	Chondrodite.	1·507	Cancrinite.
1·719	Hornblende, basaltic.	1·62	Topaz.	1·507	Leucite.
		1·609	Eudialyte.	1·496	Hauyne.
1·718	Ottrelite.	1·601	Calcite.	1·487	Analcite.
1·715	Spinel.	1·591	Biotite, black.	1·486	Natrolite.
1·705	Astrophyllite.	1·59	Clinochlore.	1·483	Sodalite.
1·701	Barkevikite.	1·587	Anhydrite.	1·476	Tridymite.
1·70	Zoisite.	1·585	Muscovite.	1·46	Nosean.
1·699	Hypersthene.	1·583	Meionite.	1·44	Opal.
1·688	Diallage.	1·580	Anorthite.	1·434	Fluorite.
1·683	Diopside.	1·577	Chlorite.		
1·679	Olivine.	1·567	Antigorite.		


0mm·00
0mm·01
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0mm·04
0mm·05
0mm·06
Iron Gray.
Pale Gray.
Pure White.
0·005.
Pale Yellow.
Bright Yellow.
Orange Red.
Red.
Violet (sensitive tint No. 1).
0·010.
Blue.
Bluish Green.
Green.
Yellowish Green.
0·015.
Yellow.
Orange Red.
Red.
Violet (sensitive tint No. 2).
0·020—Blue.
Bluish Green.
Green.
Yellowish Green.
Yellow.
0·025—Rose Red.
Reddish Carmine.
Purplish Carmine.
Violet Gray (sensitive tint
Bluish Gray No. 3).
0·030—Brownish Green.
Pale Green.
Pale Gray.
0·035.
White of higher order.
0·040.
0·300
0·200
0·160
0·120
0·100
0·080
0·070
0·065
0·060
0·055
0·050
0·045
First order.
Second order.
Third order.
Fourth order, etc.

ART. XXVII.—*Studies in the Cyperaceæ;* by THEO. HOLM. XIV. On a collection of *Carices* from Alaska with remarks upon the affinities of *Carex circinata* C. A. Mey. and *C. lejocarpa* C. A. Mey. (With figures in the text.)

AMONG the very extensive botanical collections, which Dr. Walter H. Evans brought from Alaska during the summers of 1897 and 1898, were several *Carices*, which were kindly donated to the writer, and upon which we have prepared the following paper. The Alaskan coast with adjacent islands has for many years been known to possess an unusually rich vegetation of *Cyperaceæ*, especially *Carices*, and a considerable number of highly interesting species are recorded in the works of Boott, Hooker, Ledebour, Macoun and Meyer.* Several of these species are absolutely local and their geographical range is thus confined to some of the small islands or to a few localities on the main land; some others are found, also, on the Asiatic side of Bering Sea; a few are distributed throughout the northern part of Asia, Europe and this country, while some of these species are even arctic and circumpolar. The following species were collected by Dr. Evans:

Carex macrocephala Willd.

Many gigantic specimens with spikes 7^{cm} in length and over 4^{cm} in thickness; the species is considered as dicœcious by Franchet, who examined a large number of specimens from eastern Asia, but among those collected by Dr. Evans there were several individuals with purely staminate and pistillate spikes on the same plant.

var. *bracteata* Holm nov. var.

The bracts of the inflorescence developed into green leaves, about 10^{cm} in length.

Common in sand along shore, Kussiloff.

C. Macloviana d'Urv. var. *Haydeniana* (Olney).

On flat at Feeny's ranch, five miles from Kadiak.

C. canescens L.

Common about Sitka.

var. *polystachya* Bail.

In low places, Unalaska.

* For references consult the bibliography appended to this article.

C. cryptantha Holm nov. sp. (fig. E).

Roots very slender; rhizome short, cespitose; culms numerous until 45^{cm} in length, triangular, scabrous above; leaves shorter than the culm, about 25^{cm} in length, narrow, flat, scabrous along the margins and on the lower surface, their sheaths short, pale brown, thin in texture, not fibrillose; inflorescence very short, from 1½ to 2^{cm} in length, consisting of 2 or 3 contiguous, sessile, reddish-brown spikes, mostly androgynous with a few female flowers at base; bracts scale-like, obovate, brown, membranaceous, the midrib sometimes excurrent as a bristle-like awn; scales of staminate and pistillate flowers (fig. F) broadly elliptic, acute, shining reddish brown, pointed, the margins hyaline; utriculus (fig. G) rather broadly elliptic, attenuated at both ends, pale brown, glabrous, coriaceous, with several, distinct nerves, the beak short, entire; caryopsis dull and brown, roundish in outline, almost flat; stigmas 2.

In dense mats along small streams between Kussiloff and Kenai. Its nearest ally is *C. heleonastes* Ehrh., from which it differs in its narrow inflorescence and shining reddish brown scales, which are larger and much broader, almost entirely concealing the utricle.

C. læviculmis Meinsh.

This species has been known for many years, but has not been well understood; it was referred to *C. elongata* by Bongard; to *C. remota* by Treviranus, and as "potius *C. glareosa*" by Ruprecht, while L. H. Bailey described it as a variety *sparsiflora* of *C. Deweyana* Schw. It was not until 1893 that Meinshausen segregated it as a species, and his diagnosis reads as follows: "Radix cæspitosa, fibrosa; culmis tenuissimis acute triquetris, 1--1½ ped., flaccidis lævissimis inferne foliatis; foliis linearibus planis, infimis brevissimis, summis dimidio culmi subæquantibus; spica elongata, spiculis 4–8 subglobosis remotius interruptis, infima sæpe valde remota, ferrugineo—viridibus, basi masculis; bracteis squamæformibus, ima setacea longe aristata rarius foliacea spiculæ 2–3—plo. excedente; perigyniis ovatis rostro acuminato, ore minimo integro, plano convexis marginibus acutis scabris, utrinque rubro nervatis patulis, apice paulo incurvatis demum ferrugineis, squama ovata acuta v. acuminata ferruginea acute carinata paulo breviora."

The specimens examined by Meinshausen were from Sitka and Kamtschatka (legit Mertens). Dr. Evans collected it on edges of bogs on cleared lands, Wrangell; along the beach above high tide, Howkan; in woods, common, Kussiloff.

The species has, furthermore, been collected by Thos. Howell in marshes by Yes Bay, Alaska, and by John Macoun in the vicinity of Comox, Vancouver Island. Rev. G. Küken-

Carex lugens (A–D) and *C. cryptantha* (E–G) natural size.

thal informs us (in litteris) that he has, also, seen specimens from Idaho, Washington and Oregon, which he considers identical with this species.

C. polytrichoides Muhl.

Edge of marsh, Kussiloff.

C. tenella Schk.

In marsh, not abundant, Kussiloff.

The specimens are somewhat shorter and more robust than the typical plant from Scandinavia and Rocky Mountains, but the structure of the spikes and utriculus is the same.

C. circinata C. A. Mey.

On rocky hilltops, 900 to 1200 feet alt., Kadiak.

This species is one of the very rarest, and has only been found a few times before, perhaps not very far from where Dr. Evans collected it. Meyer, who is the author of the species, gives the locality only as "in rupibus Unalaschkæ," while Prescott, who described the Cyperaceæ for Bongard, states that it was found on "the island of Sitcha"; according to Ledebour, Redowsky is credited with having collected the plant somewhere in Kamtschatka, though with a query. In later years Professor John Macoun has reported the species as having been found by Barclay near Sitka, but these specimens, which we have seen, do not belong to *C. circinata*, but to *C. pyrenaica* Wahlbg.; the species occurs, however, on the Shumagin Islands, where it was collected by Mr. Harrington in 1871–72, and of which a few specimens are preserved in the National Herbarium. But we find no record of it in Trautvetter's works, in Kjellman's or Franchet's, nor is it included in James Macoun's list of plants from the Pribilof Islands. The species must be very local, and seems to be confined to the Alaskan coast with adjacent islands.

C. Gmelini Hook.

Among rocks on beach, Sitka; on flats, Kussiloff; abundant at Homer, Cook inlet.

C. nigella Boott.

A very few specimens were collected on Kadiak, where it grew together with *C. circinata*.

C. vulgaris Fr.

Growing in small tufts in wet places, Wrangell.

C. interrupta Bœckl.

Abundant at Wrangell, grows in dense tufts.

C. lugens Holm, nov. sp. (fig. A).

Roots thick, very hairy; rhizome ascending, stoloniferous; culm from 30 to 45^{cm} in height, slender, but stiff, sharply

triangular, scabrous; leaves shorter than the culm, narrow and flat, scabrous along the margins and the lower surface; spikes 3 to 4, contiguous: one terminal staminate, 2 or 3 lateral pistillate; staminate spike peduncled, about 2^{cm} in length, the scales (fig. B) obovate-oblong, obtuse, dark brown with hyaline margins, the midrib pale, not excurrent; pistillate spikes erect, very dark, short, only 1 to 2^{cm} in length, densely flowered, the upper sessile or nearly so, the others peduncled; bracts not sheathing, very short and filiform; scale of pistillate spike (fig. C) obovate and acutish, black with very narrow hyaline margins, midrib not excurrent, barely visible; utriculus (fig. D) glabrous, a little longer than the scale, thin in texture, round obovoid with a minute entire beak, purplish above, pale green below, nerves barely visible; caryopsis obovate, flat; stigmas, 2.

Common in drier places on bay, Kussiloff.

Related to *C. cæspitosa* Good., but is at once distinguished from this by its stoloniferous habit and darker colored spikes. *C. cæspitosa* grows always in dense tufts and the culms are at the base surrounded by purplish, bladeless sheaths, besides that the utricle is pale green.

C. cryptocarpa C. A. Mey.

Abundant near villages, Sitka; on sands with *Elymus*, Kussiloff; in wet places near beach, Wrangell and Howkan.

C. macrochæta C. A. Mey.

In bogs at Sitka, 1000 feet above sea-level; on mountain top about 1200 feet, Kadiak.

C. salina Wahlbg. var. *cuspidata* Wahlbg.

On flat in rich soil, Kussiloff. The specimens were low, from only 10 to 17^{cm} in height, but agree very well with the Norwegian plant; it is very interesting to notice that the species exhibits exactly the same variation in Alaska as in Norway, thus the var. *reducta* (Drej.) has been collected by Mr. James M. Macoun on St. Paul Island, while the var. *hæmatolepis* (Drej.) was collected on the same island by Mr. Thos. H. Kearney Jr.

C. stygia Fries.

Common on flats near edge of bog, Kussiloff; in bogs and wood meadows, Howkan, Sitka.

C. livida Willd.

In rather dry places, Sitka. Specimens very tall, reaching until 30^{cm} in height.

C. pauciflora Lightf.

Abundant in bogs, Sitka.

C. utriculata Boott.

On bog, Sitka.

C. physocarpa Presl.

Common at Kadiak on rather dry mountain side at an elevation of 500 feet. The specimens seem better referable to this species than to *C. compacta* R. Br., but neither this or *C. physocarpa* is well understood, thus the identification is very uncertain.

In considering the geographical distribution of some of these species, the following are circumpolar: *C. canescens*, *C. vulgaris*, *C. salina* and partly, also, *C. livida*; *C. cryptocarpa* is very common on the western and eastern coast of Bering Sea, and extends as far south as Japan and China, but it is otherwise known only in Greenland, Iceland, Farœ Islands and a few places on the Norwegian coast; *C. stygia*, which seems to be very abundant in several parts of Alaska has not, so far, been recorded with certainty from other countries than Finmark in Norway. *C. tenella*, which has a very wide distribution in North America, from the Atlantic to the Pacific Ocean, does not occur in Greenland, is rare in Scandinavia and Arctic Russia, has not yet been reported from Arctic Siberia, and is first met with again in Kamtschatka. *C. macrocephala* and *C. Gmelini* are only known from the eastern and western coast of Bering Sea but both extend as far south as Japan, the former even to China; *C. macrochæta* has been collected in many places on the Alaskan coast, but not, so far, on the Asiatic side, unless Kjellman's specimens from Konyam Bay may be referred to this rather than to *C. podocarpa* R. Br. *C. Macloviana* shows an exceedingly wide distribution ranging from Alaska southwards to Magellan, besides that it occurs, also, on Sandwich Islands, in Greenland and Arctic Europe. *C. nigella* is only known from Alaska and the Rocky Mountains in middle Colorado; *C. interrupta* is only known on this side of Bering Sea: Alaska and Oregon.

The very considerable material of the rare *C. circinata*, which was placed at our disposal, induced us to study its affinities, inasmuch as we received, also, a number of excellent specimens of its nearest ally, the equally rare *C. lejocarpa* C. A. Mey., for which the writer is indebted to Mr. James M. Macoun, who, some years ago, detected this species on the Pribilof Islands in Bering Sea.

These two species resemble each other very much, but are, nevertheless, readily distinguished by the following characters:

The rhizome is horizontal and creeping in *C. lejocarpa*, but cespitose in the other; the leaves are flat and straight in the former, but almost filiform and "circinate" in the other; the utricle has a hyaline bidentate beak in *C. circinata*, but a merely truncate in the other. As regards the distribution of the sexes, the spike was found to be androgynous in all the specimens, several hundreds, which we have examined of *C. circinata;* in *C. lejocarpa*, on the other hand, we have found specimens that were truly *diœcious*, and others in which the spike was androgynous, the latter being quite scarce. The number of stigmas varies in both, and we observed two and three in the same spike of *C. circinata*, three being, however, the commonest; in *C. lejocarpa* we noticed two stigmas in only two specimens.

In making our first disposition of these species we did not hesitate to place them among the "*Carices genuinæ*," not only on account of the number of stigmas being mostly three, but especially because the external structure and coloration of the spike suggested affinities to certain species of *Carex* proper rather than of *Vignea*. However it is often very difficult to decide where to place some of these little, monostachyous species, and one is often most inclined to consider the number of stigmas as much more important than it really is. The distigmatic monostachyæ are thus generally placed among the "*Vigneæ*" as representing small sections of their own, as, for instance, the *Capituligeræ* of Rev. G. Kükenthal, to which are referred *C. nardina*, *C. capitata*, *C. pulicaris*, and others, yet the *C. nardina* of the Rocky Mountains in Colorado has most often three instead of two stigmas, and as we have stated above a similar variation exists also in both *C. circinata* and *C. lejocarpa*. We should prefer to compare the structure of utriculus besides the shape and relative size of the scales and bear in mind that the formerly so-called "*Psyllophoræ*" in most cases may be referable to the higher developed "greges" not only among "Carices genuinæ," but also among "Vigneæ," as illustrated by Drejer and Boott in various instances. And in regard to our two Alaskan species, no Caricologist can possibly deny that their spikes, considered by themselves, show a striking resemblance to those of *C. sempervirens* Vill. and its allies. We have, also, but so far in vain, tried to establish some connection between them and *C. nigricans*, *C. pyrenaica*, *C. macrostyla* and *C. pulicaris;* the affinities of these species with their deciduous squamæ and reflexed utricles may, perhaps, be sought among some of the higher forms with squarrose spikes.

In our further disposition of *C. circinata* and *C. lejocarpa* we have considered them as "*formæ hebetatæ*" of that section

to which *C. sempervirens* is supposed to belong, the affinities of which may naturally be sought among such boreal or alpine forms as *C. misandra* R. Br., *C. frigida* All., *C. ferruginea* Scop., etc. The systematic position of these species is not defined in Drejer's work, but he makes some allusions to a possibly existing affinity between *C. circinata*, *C. Davalliana* on the one side and *C. sempervirens*, *C. misandra* and *C. frigida* on the other, while he enumerates these as "*formæ desciscentes*" under "*Melananthæ*." However, on his table of affinities III Drejer places these between "*Sphæridiophoræ* and *Lamprochlænæ*," and he evidently considered them as representing a section or grex of their own; the work, however, which this author began in such an admirable manner was, unfortunately, never finished. In Tuckerman's "Enumeratio methodica" we find some of these species classified as "*Fuliginosæ*" (*C. fuliginosa* and *C. frigida*) and as "*Ferrugineæ*" (*C. ferruginea*, *C. sempervirens*, *C. brachystachys* and *C. firma*), while he does not seem to have known *C. lejocarpa* or *C. circinata*. A similar disposition is, furthermore, to be noticed in Dr. Christ's Catalogue, where these same species are arranged in one section "*Frigidæ* of Fries," together with *C. mucronata* All. and *C. brachystachys* Schrank. The *Frigidæ* are taken up again by Rev. G. Kükenthal, placed between *Sphæridiophoræ* and *Hymenochlænæ*. Still another, but most unsuccessful classification is proposed by Professor Bailey, who includes all the *Frigidæ* in *Microrhynchæ*, which he, furthermore, combines with *Æorastachyæ*,* *Melananthæ* and *Trachychlænæ* (*C. glauca* Scop.) of Drejer, while *C. circinata* and *C. lejocarpa* are placed under a new section *Leptocephalæ* Bailey including *C. polytrichoides!* It does not seem necessary to discuss further such combination, which is in no respect in accord with the system proposed by Drejer, to whom Professor Bailey refers as author of these various sections.

It appears as if the *Frigidæ* may really constitute a special section, as proposed by Dr. Christ and Rev. G. Kükenthal, but we do not know how far Mr. Kükenthal extends this section, since this author has only treated the South American *Carices*, of which only one, *C. Vallis pulchræ*, is enumerated. However, by examining the European and boreal species of this section, we have noticed that certain and, indeed, very striking analogies exist between them; moreover, the utriculus may be well referable to one single type in all of them. This organ is in these species more or less trigonous in transverse section; it is membranaceous, usually glabrous or sometimes a little

* The sectional name *Æorastachyæ* (*αἰώρα*) as proposed by Drejer is by Professor Bailey constantly cited as "Ærostachyæ."

scabrous above; it is generally attenuated at both ends, and the orifice of the beak is mostly bidentate with erect teeth, or entire, oblique. The nerves are seldom distinct, and the coloration may vary from green to deep purple or brown; thus the spikes in some species attain the same dark aspect as is characteristic of the *Melananthæ*. Another character common to these European and boreal species is the position of the pistillate spikes, being more or less remote and nearly always borne on very conspicuous peduncles, in some species of quite considerable length and nearly filiform. The sheaths of the bracts are well developed, and in regard to the general habit, these species exhibit but a few divergences, which, however, may be considered as analogous deviations, such as we know exist in some of the other sections. The terminal spike is sometimes gynæcandrous or androgynous in *C. brachystachys* and, as it seems, constantly gynæcandrous in *C. misandra;* in all the other pliostachyous, which we have examined, the terminal spike is purely staminate. Such varied distribution of the sexes is also met with among the *Melananthæ*, the *Hymenochlænæ* and the *Spirostachyæ*. And if we, moreover, consider *C. lejocarpa* and *C. circinata* as members of the *Frigidæ*, we then perceive a still more gradual variation among the species themselves: from the diœcious *C. lejocarpa* to *C. circinata* with androgynous spike, and to *C. sempervirens* and its very nearest allies with unisexual spikes, borne on the same culm, to *C. brachystachys* with occasionally androgynous or even gynæcandrous terminal spike and *C. misandra* with its invariably *gynæcandrous*. Abnormally decompound pistillate spikes, as these are frequently met with in several of the other sections, have also been noticed in some of the *Frigidæ;* Boott records such cases from *C. brachystachys*, and we have, furthermore, found these in *C. ablata* Bailey and in one single inflorescence of *C. circinata*.

In looking over the various sections, as these are described by Drejer, we have not been able to find any under which the *Frigidæ* might be properly arranged. They seem to possess some characters common to the *Hymenochlænæ*, yet lacking the essential character of these: "perigynia plerisque nervata, rostro apice hyalino bilobo—bifidove, vel distincte bifido," besides "squamæ membranaceæ albidæ" and "color plerumque læte viridis." And in comparing them with the *Spirostachyæ* certain analogies seem to exist; for instance, the darker color of the spikes, the mostly erect and remote, pistillate spikes, while "perigyniis distincte bifidis" and "spicis densifloris quasi squarrosis" are not possessed by the *Frigidæ*. We have not, on the other hand, been able to detect any intergradating forms between these three sections, by which the *Frigidæ*

might be connected as "lesser" or "higher" developed types; on the contrary, it seems as if we in the *Frigidæ* themselves might trace some of their earlier types represented by, for instance, *C. lejocarpa*, that we might count *C. sempervirens* and *C. frigida* among their central forms, while *C. misandra* may be looked upon as a "*forma desciscens*," yet possessing the most essential characters of the section.

While thus fully recognizing the maintenance of these species as representing a section of their own, we should prefer not to adopt "*Frigidæ*" as the sectional name but one in Greek which, moreover, would be in stricter conformity with those suggested by Drejer for the other sections. And when we suggest "*Stenocarpæ*" as a more proper name, this refers not only to the characteristic shape of their utriculus, but also to one of the central forms, "*Carex stenocarpa*" of Turczaninow, the Asiatic homologue of *C. sempervirens*. The principal characteristics of the section, drawn from the central forms, are as follows:

Carices stenocarpæ.

Terminal spike staminate; lateral ones pistillate, distant, peduncled, erect or finally drooping. Bracts distinctly sheathing, mostly filiform, short. Utricle membranaceous, glabrous or a little scabrous above, narrowly attenuated at both ends; orifice of beak bidentate with erect teeth or obliquely cut, often hyaline; stigmas 3, achenium trigonous. Boreal or alpine species with mostly dark-colored spikes. The lesser developed, monostachyous types (*C. lejocarpa* and *C. circinata*) remind of certain *Vigneæ*, the central of *Spirostachyæ*; at the limits of the section are types (*C. misandra*, *C. brachystachys*) with androgynous or gynæcandrous terminal spikes, which remind of certain *Melananthæ* (*C. atrata*, *C. Mertensii*).

Among the species which represent this section may be enumerated:

Hebetatæ
- *C. lejocarpa* C. A. Mey.
- *C. circinata* C. A. Mey.

Centrales
- *C. sempervirens* Vill.
- *C. frigida* All.
- *C. ferruginea* Scop.
- *C. ablata* Bail.
- *C. firma* Host.
- *C. hispidula* Gaud.

Desciscentes
- *C. brachystachys* Schrank.
- *C. misandra* R. Br.

To these may possibly be added some others, of which we have seen no specimens, but judging from the diagnoses and

illustrations, we suppose that they may be regarded as members of this section: the monostachyous *C. hakkodensis* Franch., *C. rhizopoda* Maxim., *C. heteroclita* Franch. and *C. grallatoria* Maxim. all from Japan; *C. Vallis pulchræ* Phil. from South America, and *C. acicularis* Boott from New Zealand; finally the pliostachyous *C. hæmatostoma* Nees, *C. psychrophila* Nees and *C. macrogyna* (Turcz.) from northern India. Boott himself considered *C. macrogyna* as being an ally of *C. sempervirens*, but states that in the former the uppermost spikes are sometimes androgynous. In regard to *C. hirtella* Drej., *C. hæmatostoma* and *C. psychrophila* Boott compares, also, these with the *Ferrugineæ* Tuckm., as representing on the mountains of northern India those analogous species found on the Alps of Europe. *C. grallatoria* is, according to Maximowicz, a close ally of *C. lejocarpa*.

The *Stenocarpæ* constitute a small, very limited section, and the types are either alpine, arctic or confined to the coasts of the Pacific from Bering Sea to Japan. *C. misandra* exhibits the widest range in geographical distribution; besides being circumpolar, this species occurs on the mountains of both northern and middle Europe and on the Rocky Mountains as far south as middle Colorado. The central forms, excepting *C. ablata* from Vancouver Island, are confined to the European Alps or, if we include those cited by Boott, to the mountains of India. Finally, as mentioned above, there is a species in South America and one in New Zealand, both with a single, androgynous spike, which Mr. Kükenthal considers as belonging to this same section, with him the *Frigidæ* of Fries.

There is, thus, considered from a geographical viewpoint, a wide gap between the "*hebetatæ*" and "*centrales*;" yet, as we have stated above, there is one of the latter which inhabits Vancouver Island; moreover by including the Japanese representatives of "*hebetatæ*" these are not so very remote from their higher developed allies on the mountains of northern India. The Pyrenees and middle European Alps possess, on the other hand, types which are very isolated and are only connected with their northwest American allies through *C. misandra*. The most gradual development of the section may, thus, be traced in Asia and in the northwestern corner of America, where all the types occur: *hebetatæ*, *centrales* and *desciscentes*. But we have no species of this section in Europe, which as *C. lejocarpa* may point towards some fundamental types of the recent time, and the *formæ centrales* of the European mountains, *C. sempervirens*, etc., may be considered as representing the remnants of an old center of which the earlier types have disappeared long ago, but leaving a group of species, the highest developed in the section.

While thus the *Stenocarpæ* represent a very natural little group of *Carices* in respect to their external, morphological, characters, we have, furthermore, examined the anatomy of some of these species, which seems to be very uniform. Whether uniformity in anatomy, however, may be considered as being an absolute necessity for the establishment of sections of Carices to which morphological peculiarities are in common, is by no means certain. We will, no doubt, meet with many exceptions by extending our studies to several of the other and larger sections, as for instance the *Melananthæ* and *Microrhynchæ*, the members of which exhibit so many diverse types from the extreme north and south, and living under very different conditions as to climate and soil. It is, also, very possible that several of the smaller sections may be found to possess a like structure in anatomical respects, yet being apparently distinct when considered from a morphological viewpoint. This is readily noticed from the literature on this subject, the works of Mazel and Lemcke. The former of these authors has examined the structure of the root, the stem and the leaf of 43 species of *Carex*, nearly all from Europe, and his final conclusion is thus expressed: "On ne peut en aucun cas se baser sur des caractères anatomiques pour grouper systématiquement les espèces dans le genre *Carex*"; yet it does not seem as if this author has made any attempt to deduct a classification from his anatomical results. The other author, Alfred Lemcke, who has examined the rhizome and the aboveground stem of about 160 species of *Carex* from Europe and this country, believes, on the contrary, in the possibility of classifying *Carices* from the structure of their rhizomes, and considers Dr. Christ's system as the most practical for this purpose. The *Frigidæ* Fr. including *C. mucronata* All. are, thus, considered as being closely related to each other, while we find *C. circinata* enumerated under *Psyllophoræ* among such species as: *C. gynocrates*, *C. capitata*, *C. polytrichoides* and even *C. Fraseri*. However we doubt very much whether any conclusion may be drawn from the structure of the rhizome alone or from the stem so as to establish sections or smaller groups of *Carices*. Nevertheless the works of these two authors constitute a valuable contribution to our knowledge of the anatomy of *Carex*, even if their results do not bear directly upon the classification.

In regard to our *Stenocarpæ* we are, thus, well aware of the possibility that the anatomical characterization which we present as supplemental to the morphological, may also contain several points that are common to some of the other sections. These anatomical notes may, nevertheless, become useful to further studies of the genus, at least as a contribution

to similar investigations. As regards the material which we have examined, the specimens were collected in the following localities:

C. circinata C. A. Mey., rocky hilltops, 360–375^{m} alt., Kadiak; *C. lejocarpa* C. A. Mey., grassy banks, St. George Island, Bering Sea, and marshes at Yes Bay, Alaska; *C. sempervirens* Vill., Alps of Switzerland, Tyrol; *C. ferruginea* Scop., along streams, 2000^{m} alt., *C. frigida* All., 2300^{m} alt., *C. firma* Host., 2000^{m} alt., *C. hispidula* Gaud. 2100^{m} alt. and *C. brachystachys* Schrank, 1260^{m} alt., all from the Alps of Switzerland; *C. ablata* Bailey, 600^{m} alt., Vancouver Island; *C. misandra* R.Br., St. Mathew Island, Bering Sea; along mountain streams on Gray's Peak, 4000^{m} alt., Colorado; on dry, grassy mountain slopes or swamps, West Greenland; Rendalen, Spitzbergen; in swamps on rocks, Nova Zembla; Alps of Tyrol at 3000^{m} alt.

The root.

In the species examined we found the roots very strongly built with a more or less thick-walled hypoderm inside the epidermis. The outermost strata of the cortex show a similar thickening and constitute thus a firm sheath around the inner bark, which is thin-walled and usually collapsed throughout to the innermost stratum that rests on endodermis. In *C. sempervirens* the outer six strata of the cortex were especially heavily thickened, also in *C. hispidula*, in which even the innermost four or five strata exhibited a like thickening, while in *C. firma* the entire cortical parenchyma was developed as a solid mass of stereïds. Endodermis is thick-walled in all the species but not to the same extent; thus an U-endodermis may be found in *C. lejocarpa*, *C. circinata*, *C. misandra*, *C. hispidula* and *C. sempervirens*, while it appears as a V-endodermis in the remaining species; the thickening is especially heavy in *C. firma* and *C. sempervirens*. The pericambium is most often thin-walled, or in some roots of *C. firma*, *C. frigida* and *C. sempervirens* the cell-walls may be observed as being somewhat thickened. It consists of only one stratum, which forms a closed ring in *C. sempervirens* and sometimes also in *C. firma*, but is, in the other species, interrupted by the proto-hadrome vessels in a more or less regular manner. We have noticed the following cases: In *C. circinata*, *C. lejocarpa*, *C. misandra*, *C. frigida* and *C. ablata* the pericambium was constantly interrupted by all the proto-hadrome vessels, there being mostly four or five pericambium cells between each two of these vessels. In *C. hispidula* we found in some roots the pericambium interrupted by all the proto-hadrome vessels or by only five out of twenty-five, and these roots were from the

same individual; the number of pericambium-cells between each two vessels varied in this species from four to seven, but four and five was the commonest. This peculiar case was, moreover, noticed in other specimens from a still higher elevation (2800^{m} Mt. Ryssel), in which sometimes most of the proto-hadrome vessels were situated inside the pericambium, and only a very few bordered on endodermis. In *C. firma* a similar and very irregular position was noticed, since the pericambium was either not interrupted at all or it was broken by the majority of the vessels, by 14 out of 15. In *C. brachystachys* we found no case where the pericambium was not interrupted, but the position of the proto-hadrome was very irregular even in the same root, cut at different places. The number of interruptions varied thus between 8 and 13, while the distance between the places where the sections were made was about 5^{cm}; in most of the roots of this species, however, we observed that the majority of the proto-hadrome vessels were located inside the pericambium, and only in one root did we notice that fourteen out of nineteen bordered on endodermis. In *C. ferruginea* Scop. we observed that all the proto-hadrome vessels bordered on endodermis in roots of very different thickness, but in a single root the following position was noticed: 25 out of 26 vessels had broken through the pericambium, but at the other end of the same root there were only 18 of these 25 vessels that bordered on endodermis.—*C. hispidula*, *C. ferruginea* and *C. brachystachys* illustrate thus the singular fact that the pericambium is very irregularly interrupted by the proto-hadrome, but, on the other hand, we found no cases in these species where it was not interrupted at all. *C. firma*, on the contrary, possesses roots in which the pericambium may sometimes form a closed ring or it may be broken by nearly all the proto-hadrome vessels. This singular instance is, moreover, to be observed in roots of *C. supina* Wahlbg. in some specimens which we collected in West Greenland; the species belongs, however, to another section, evidently to the *Lamprochlænæ* Drej., which we intend to discuss in a subsequent paper.—But we have not so far noticed any such variation in any of the other *Cyperaceæ* which we have heretofore examined. In regard to the other vessels in the roots of these species we have not found any occupying the center of the central-cylinder, with the exception of small, lateral roots, which usually possessed only one central vessel. The conjunctive tissue which thus occupies the innermost part of the central-cylinder is distinctly thick-walled in all the species, with the exception of *C. ablata*, where it is thin-walled even in such roots of which the endodermis shows the cell-walls to be very considerably thickened. The leptome, includ-

ing the proto-leptome, was very well developed in all the species and was located between each two proto-hadrome vessels.

In examining the above-ground stem we find that it does not exhibit such striking divergences as was noticed in the roots. Sections taken from about the middle part of the culm showed the outline to vary from cylindrical to sharply triangular as follows: it was found to be terete and nearly glabrous in *C. circinata*, *C. sempervirens* and *C. brachystachys*; pentagonal and almost glabrous in *C. ferruginea*; obtusely triangular and glabrous in *C. ablata*; triangular and nearly glabrous in *C. lejocarpa*, *C. misandra* and *C. frigida*, while triangular and very scabrous in *C. firma* and *C. hispidula*. The cuticle is quite thick and perfectly smooth, not wrinkled in these species. The epidermis shows generally a distinct thickening of the outer wall, especially in *C. sempervirens* and *C. ablata*; the radial cell-walls are a little thickened in *C. ferruginea*, *C. frigida* and *C. ablata*. Cone-cells were found outside the hypodermal stereome in all species; stomata occurred frequently in that part of epidermis which covered the bark and showed the same structure as in the leaves, which will be described later. A somewhat peculiar epidermal structure is represented by *C. hispidula*, where the outer wall in nearly all the cells was noticed to be extended into roundish papillæ, especially near the stomata, although not covering these. The cortical parenchyma is mostly developed as short palisades, radiating towards the center of the stem, and contains lacunes, sometimes of quite considerable width in *C. circinata*, *C. lejocarpa* and *C. hispidula*. The stereome occurs as hypodermal groups, covering the larger mestome-bundles, but is also to be found on the hadrome side of these, bordering on the pith. The smaller mestome-bundles have usually only a minute support of stereome, this being merely developed as a few cells on either face of these. This tissue, the stereome, is very thick-walled, at least on the leptome-side, in *C. circinata*, *C. sempervirens*, *C. hispidula*, *C. firma*, *C. frigida* and *C. brachystachys*, much less so in the remaining species, and it is generally rather open on the hadrome-side of all the mestome-bundles.

The mestome-bundles are developed as larger, in transverse sections oval, or as smaller, nearly orbicular, and are arranged in almost regular alternation with each other. They constitute in most of the species only one peripheral band, but in *C. hispidula*, *C. ablata* and *C. brachystachys* we noticed an inner band of a few, 3 to 5, large bundles, almost entirely imbedded in the pith. The parenchyma-sheath is invariably thin-walled and seems often to contain chlorophyll; a mestome-sheath with the inner walls distinctly thickened is also noticeable in all the

species; but we found no trace of the inner green sheath, which we remember is known to occur in many genera of the *Cyperaceæ*, but not so far known from any species of *Carex*.

There is a central, thin-walled pith in all the species, and this seems to break down, leaving a wide central cavity in all the species examined, with the exception of *C. circinata*.

The leaf.

The leaf exhibits a somewhat greater variation than is noticeable in the stem. The narrowest leaf-blade is possessed by *C. circinata* and *C. brachystachys*, but if we consider the sections taken from the middle of the blade, this is in none of these so narrow that it might be described as semi-cylindrical. The surface of the leaf is very smooth in most of the species, but in *C. hispidula* the blade is somewhat constricted between the mestome-bundles, besides that the epidermis in this species is very scabrous on either face. In *C. brachystachys* the lateral parts of the blade are much thicker than the mediane, and very large prickle-like projections are developed on the upper surface on each side of the bulliform-cells. The leaf-surface is thus mostly smooth with no deep furrows, but it is scabrous from prickle-like projections in *C. sempervirens*, *C. ferruginea* and *C. brachystachys;* in *C. hispidula* both surfaces are quite scabrous from the numerous papillæ, which also characterized the stem of this species. Bulliform-cells occur on the whole upper face of *C. circinata* and *C. lejocarpa*, but these cells are in the other species restricted to a single group just above the midrib; the outer cellwall of epidermis is very thick in some species, for instance, *C. hispidula*, *C. frigida* and *C. firma*, but not so in *C. ablata*. Some certain variation exists also in the relative length and breadth of the epidermis-cells outside the stereome, and this is especially distinct when we examine the leaf in superficial sections; we notice, for instance, in *C. ferruginea*, *C. brachystachys* and *C. misandra* that these cells are narrower, but not shorter, than the surrounding epidermis, while in *C. sempervirens*, *C. frigida* and *C. hispidula* they appeared to be much shorter but not narrower. In *C. firma* and *C. ablata* these same cells, covering the stereome, were distinctly both narrower and shorter than the stomatiferous strata.

In regard to the stomata, these are in the *Stenocarpæ* confined to the lower surface of the leaf, and show a very uniform structure; they are free in all the species, slightly projecting in *C. misandra*, *C. firma* and *C. ablata*, but level with epidermis in the others; in *C. hispidula*, as mentioned under the

stem, the stomata are surrounded by mostly four papillæ, which, however, are quite short and not bent over the stoma, thus this is almost free as in the other species. This structure of the subsidiary cells with their papillæ in *C. fimbriata* has already been described by Schwendener in his paper on the stomata of the *Gramineæ* and *Cyperaceæ*.*

The mesophyll is either represented as a homogeneous tissue throughout the leaf, as in *C. circinata* and *C. lejocarpa*, or it is differentiated into a more or less distinct palisade-tissue on the upper face and a more open, pneumatic on the lower, as in *C. ferruginea;* in the other species the palisades are short and not so regular, but appear nevertheless to be placed vertically on the blade, with the exception of *C. ablata*, in which the palisade-cells show a tendency to radiate towards the center of the mestome-bundles. Lacunes were observed in all the species, one between each two mestome-bundles, and they were especially wide in *C. circinata*, *C. lejocarpa*, *C. misandra* and *C. hispidula*. The stereome occurs as in the stem on both faces of the mestome-bundles and as hypodermal in the larger of these; it is, moreover, to be observed as a small, isolated group in each of the two leaf-margins. It is very thick-walled in *C. sempervirens* and *C. ferruginea*, moderately so in the other species; it is rather weakly developed in *C. ablata*.

The mestome-bundles lie in one plane, and the midrib is generally somewhat larger than the others and more prominent. We find in the leaf as in the stem two forms of these bundles, larger and smaller, which show the same alternation in regard to their arrangement and the same structure as we have described under the stem.

* The position of the stomata in *Carex*, whether these are free and exposed or sunk below the surrounding epidermis and sometimes partly covered by papillæ, does not seem to be of any importance in regard to the classification of these species. On the contrary, Mazel has shown that species from the various sections of *Carex* may exhibit the same structure and position of stomata, and there does not appear to be any relation between stomata, being free or not, and the local environment, climate and soil. This author has shown, for instance, that *C. Davalliana*, *C. Pseudocyperus* and *C. hirta*, all from swamps, possess superficial stomata, while these are sunk in *C. paniculata*, *C. vulgaris*, *C. paludosa*, etc., from similar wet localities. In species which inhabit drier stations, woods and hills, a similar variation exists; thus the stomata are superficial and perfectly free in, for instance, *C. divulsa*, *C. brizoides*, *C. præcox*, *C. sylvatica*, etc., but not so in *C. maxima*, *C. glauca*, etc. A still more peculiar case may be illustrated by *C. misandra*, which we have examined from very different and remote localities: arctic and alpine regions of America and Europe, still maintaining the same structure and free position of the stomata, while in *C. capitata*, which we found growing almost side by side with this species, the stomata are protected by long and almost ramified papillæ.

It does seem as if the position of the stomata is not always an indication of the conditions of the surroundings under which the plants live, and it is, no doubt, one of the many inherited characters which are explainable only in a few species to which the natural surroundings are unchanged.

Utriculus.

The anatomical structure of this little organ appears to be very uniform in these species of the *Stenocarpæ;* it is very thin on account of the very little mesophyll, which forms here only one stratum between the two mestome-bundles, while it may be represented as two or three in the immediate vicinity of these. The outer wall of epidermis, on the dorsal face, is, however, thick in these species, while that on the ventral face is invariably very thin, like the radial walls. Stereome is also developed in the utricle of these species, but it is not very thick-walled and does not occur in groups of any considerable size either; it accompanies the two mestome-bundles, and it occurs besides as isolated groups between these, but not in all the species. In *C. misandra* and *C. frigida* the stereome was restricted to the mestome-bundles, but in the other species we found from 5 to 14 isolated groups between these; the utricle of *C. brachystachys* and *C. ferruginea* appear to possess the strongest mechanical support of these species.

In comparing these anatomical details of the *Stenocarpæ*, the species examined seem to possess a very uniform structure in spite of the fact that they were collected from very remote stations, Alaska, Colorado, Middle-Europe and the arctic region, and in the case of *C. misandra*, the specimens from Alaska exhibited the same anatomical characteristics as those from the alpine slopes of Rocky Mountains (Colorado) and Switzerland besides from the arctic region. The internal structure considered by itself is very much in conformity with that of a number of arctic plants of various orders which we have had opportunity to examine, and which seems to indicate that these species lived under conditions that were influenced by a moist rather than by a dry atmosphere. The development of the *Stenocarpæ* seems thus to have taken place, at least, in recent time, in alpine or boreal regions, where they are yet in existence, and if we combine the geographical distribution, including the nature of the surroundings, with the external and internal peculiarities of these *Carices*, we see no objection to consider *C. circinata* and *C. lejocarpa* as "*formæ hebetatæ*" of this section.

Brookland, D. C., April, 1900.

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ART. XXVIII.—*Experiments on High Electrical Resistance:* Part I; by OGDEN N. ROOD, Professor of Physics in Columbia University.

IN making electrical measurements of high resistance, if the "direct deflection method" is used, under ordinary circumstances a resistance of 5000 megohms can be measured with some degree of certainty, and if the conditions are very favorable, 50,000 megohms may be reached. The "loss of charge method" is limited by the insulation of the condenser employed, this insulation itself being equal only to about 10,000 megohms.

In the method described in this paper 5000 megohms is small resistance, and it is not till 15,000 or 20,000 megohms has been reached that the manipulation becomes particularly simple. After that, the only limit is found when the resistance is so great that the electrometer contrived by me refuses to give any indications, even with electricity of very high potential. Just what this limiting resistance is, I cannot at the present moment state, being cut off by the dampness of the air from such determinations; meanwhile, it is certain that the figure is quite high.

In the older methods of measuring resistance, a flowing current of electricity is made to act on a system of astatic needles, but in the method here proposed the electricity is allowed to slowly accumulate, till it reaches a certain potential: in the older methods the electricity is treated as though its velocity were infinite, but the present plan is based on the fact that when the resistance is very great the electricity may require ten minutes or even an hour before raising the potential of the electrometer to the required degree. Thus, while in the older methods of work the electricity in its flow resembles a quick-moving incompressible fluid, in the one here described it may be compared to that of a thick pitchy fluid, moving slowly in a long open tank, and attaining its level at the farther end of the tank after the lapse of a longer or shorter time. After its level has been attained, if a leak is made anywhere in the floor of the tank, over this leak there will be a depression of the fluid; if the hole is made in the middle of the tank, some of the fluid drawn off and the hole then stopped, the pitchy fluid will flow to the depression from both sides, but it may take minutes before the old level is once more established.

Again, if we imagine the walls of the tank to be cold and the pitchy fluid to be at a higher temperature, some of it will

harden on the walls, and to a certain extent obstruct the flow of the fluid by contracting their cross-section. This illustration corresponds to a polarizing action which often sets in, and gradually diminishes the flow of the electricity, through or over a substance of very high resistance, and the greater the resistance the larger will be this counter action. What has been said so far applies to the cases of glass, mica, paraffin paper, silk and most artificial insulating substances.

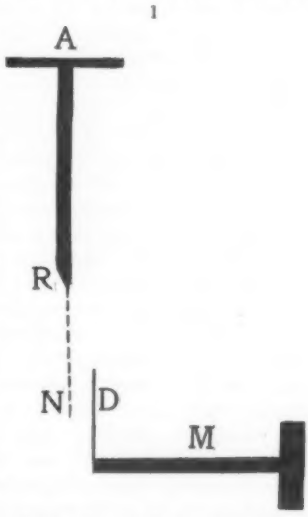
If we now imagine our tank to be quite narrow, offering thus great resistance to the passage of the pitchy fluid, then at the end where the fluid is introduced, the height or potential will equal that of the supplying source, but as the distance from this end increases, the potential falls and finally becomes zero. This case corresponds to the surface conduction of electricity by black sealing wax, jade and gutta percha. They all furnish to the electrometer only small quantities of electricity, which can only be drawn from the neighborhood of the reservoir, and here the polarization is very marked.

Finally, imagine the walls of the tank to be still farther contracted and that the pitch-like fluid refuses to enter them in perceptible quantities, and we have the cases of ebonite, ordinary rosin and exfoliated mica (in very dry weather).

Evidently, if two tanks of the same length and cross-section deliver equal amounts of the pitchy fluid in equal times, then their conducting powers should be set as equal, and in general, if there be no loss in transit, the amounts delivered per minute, by tanks differing from each other, will be a measure of their relative conducting powers. Finally, if the tanks almost refuse to deliver up any of the pitchy fluid, still, if their potentials or the heights of the fluid at various points can be measured, in a manner analogous to that employed in the study of the conduction of heat by solid bodies that have reached the stationary condition, then it becomes possible to determine their relative conducting powers, and by comparison with somewhat better conductors, an estimate of their resistance in standard units can be formed.

Apparatus.—I modified a single leaf electroscope, so that it became a serviceable electrometer for this kind of work. Its plan may be seen in the diagram. A brass rod AR was supported on a bar of ebonite, which was placed on two rods of the same substance fastened on a base of ebonite. The rods and the bar were painted with melted rosin. The rod AR carried an aluminum leaf, bluntly pointed below, and attached above to the point R by a gold leaf hinge. Aluminum leaf was used, it having been found that under the action of the minute but very numerous electrical discharges, the gold leaf slowly wasted away at its corners, which it always presented to

the plate D with an undesirable twist. D is a plate of sheet brass faced with platinum foil, and receives the charge from the aluminum leaf when its potential has been sufficiently raised. The distance of this plate from the leaf can be varied by a micrometer screw, M, and thus the sensitiveness of the apparatus regulated. When a Leyden jar was used as the source of the electricity, the plate D was connected with the earth; when the street current was employed, D was connected with one of the electric wires, a resistance of two or three thousand ohms being interposed, and as only thousands of megohms were dealt with, this amounted to nothing. An arrangement by which a slight vibration could be communicated to D was added, and by a single motion D was vibrated and the electrometer discharged by contact with A. When the electrometer gives a stroke the leaf usually remains attached to the plate D, which is the reason of the above mentioned contrivance. At A, various adjuncts can be placed, binding screws, etc. The whole arrangement amounts to a kind of unit jar which discharges itself when charged to a certain potential. Over it was placed a glass case to avoid air currents, but the case was in contact only with the base of the apparatus. Two snch electrometers were made by me, one rather large for Leyden jar experiments; the other was smaller, especially in capacity, and was used only with currents of 110 to 112 volts. Some small electroscopes on the above mentioned plan were also made; they could be set to indicate certain potentials in bodies either in contact with them or at fixed distances from them. Their capacities were quite small. I also made a Bohnenberger electroscope with its dry pile, the delicacy of which could be varied at will by moving the brass plates connected with the terminals of the pile. It was used only in the study of good insulators. The source of electricity was sometimes a Leyden jar charged to a potential of 12,000 volts, but in the measurements given in megohms a current of only 110 to 112 volts was used. This same current was employed in the preparation of standard resistances. It is to be understood that the experiments were performed in dry winter



weather, the hygrometer having a range from 12 to 30 per cent of moisture. At the end of this paper certain determinations that were made in damp weather are added.

Preliminary experiments.—The case of a sealed glass tube 1^m 30^c in length, will illustrate partially what has been said about the behavior of electricity moving over a bad conductor. When the tube was made to establish connection between a Leyden jar charged to a potential of 12,000 volts and the electrometer, the electricity advanced slowly over its entire length, the electrometer not being at all affected for some time. In about five minutes it gave regular strokes; the tube had assumed the stationary condition and had nearly the same potential over its whole length, except near the electrometer, where for 3 or 4^{cm} it was lower. For half an hour it was allowed to deliver charges to the electrometer with much regularity, the rate being observed with a stop-watch. The electrometer was then connected with the middle of the tube; at first the rate of discharge was greatly increased, as the potential was higher here than at the drained end, and the electricity was flowing into the electrometer from both sides, but in about five minutes the flow had fallen nearly to the old rate and become quite regular. An air space of a centimeter was now made between the tube and the electrometer; the latter continued to give discharges, but more slowly; the potential of the middle part that had been somewhat drained was rising and acted inductively on the electrometer, and this process continued for some minutes, till the original level had been established. The electrometer was then again connected with the farther end of the tube and matters allowed to get into a stationary condition. The strokes having become regular, the middle of the tube was connected with the ground by wet paper and wire. The electrometer strokes however continued for a considerable time, but with diminishing frequency, till the supply of electricity at the farther end of the tube had exhausted itself. In this and in all similar experiments it is to be understood that the two ends of the conducting body were provided with metallic armatures, tinfoil fastened with thread. A great many experiments were made on conductors of this class without any armatures at all; the tinfoil however facilitates matters, and makes the flow more regular.

All this illustrates the case of a glass tube with rather good insulating properties, and I pass on now to more ordinary samples. A sealed tube of hard Bohemian glass, 1^m 30^c in length, was washed in water, dried in sunshine and connected with jar and electrometer. In a second or two the electrometer began its discharges, the rate being about three seconds per stroke. The entire tube was then heated quite hot with a

Bunsen burner; for two minutes the flow of the electricity was stopped, but it then began again, the intervals between the strokes being 8, 7, 4, 3, 3, 3 seconds. Two days afterwards the experiment was repeated with a result of 10 strokes in 32 seconds. Ten days later, its rate was 10 strokes in 42 seconds. A sealed tube of soft German glass of the same length that had been carefully cleaned and heated gave 10 strokes in 20 seconds; heated again for three minutes and cooled, its rate was 10 strokes in 36 seconds and on the following day this had fallen to 10 in 15 seconds. Ten days afterwards it gave 10 strokes in 20 seconds. These slight irregularities are however thrown into the shade by an observation made on a tube of the same kind of glass, where the resistance of one-half of it was twelve times as great as that of the other, and it remained in this condition for two weeks, or until it was cleaned; then the whole of the tube had the lower resistance. A tube made from the glass that is now used in Germany for Leyden jars, was found to have a high resistance, so that the electricity did not seem to reach its farther end at all. After being in contact for three-quarters of an hour with a Leyden jar having a potential of 12,000 volts, at a distance of 16^{cm} from the jar, the potential of the tube was only 600 volts, and an additional exposure for the same length of time extended this distance only to 22^{cm}. At the time these experiments were made I had not constructed a set of units of high resistance, or it would have been easy to have measured the resistance of these tubes in megohms when traversed by a current of 12,000 volts. Later on I measured the resistance of a tube of soft German glass, 27^{cm} in length, which had been for some days in a box dried with sulphuric acid. This at first proved to be 250,000 megohms, then under the influence of the current it increased to 380,000 megohms. On this day the hygrometer indicated 43 per cent of moisture. Some time afterwards, the hygrometer indicating 53 per cent, the resistance of the tube had fallen to 180,000 megohms. The current here employed, as in all cases where actual figures are given, had a potential of only 110–112 volts.

Silk.—A double thickness of rich brown silk, 45^{cm} long, 2^{cm} broad, conducted electricity at a potential of 12,000 volts very well; the electrometer strokes began immediately, and continued hour after hour. A band of white silk was then taken, a meter in length and 3^{cc} in breadth; the discharges were at the rate of about one per second. The silk was then boiled twice in water, and dried, without affecting its rate. It was then boiled in alcohol and dried; the discharges were a little slower at first, one in four seconds, but the rate soon increased to one in two and a half seconds. Two threads of white sewing silk

failed to affect the electrometer, but with the electroscope it was found that the charge had extended over 15^{cm}. When twenty-four threads of this silk, half a meter in length, were used, the electrometer gave slow strokes needing three minutes each. A single thread of this silk was heated in a bath of one part gutta perch, three parts rosin; a large quantity of vapor bubbles escaped, and it became a good non-conductor. When it was connected with the Leyden jar, charged *positively* to 12,000 volts, not only did it not conduct, but became *negatively* electrified, with a potential of about 200 volts. Negative electrification under such circumstances will be referred to later on.

Paraffin paper.—Ordinary commercial paraffin paper, viz: writing paper which had been passed through melted paraffin wax, conducted quite well. A strip a meter in length, in fifteen minutes had acquired over its whole length a potential of about 12,000 volts. Some measurements were made of short strips of this paper provided with metallic armatures, a potential of only 110 volts being employed.

Length.	Breadth.	Resistance in megohms.
25^{mm}	18^{mm}	80,000
63^{mm}	"	125,000
132^{mm}	"	300,000

It is evident that the resistance of the connecting armatures has influenced these results.

Mica.—Using a potential of 12,000 volts, a strip of mica (muscovite) 30^{cm} long and 2^{cm} broad, was compared with a strip of paraffin paper of the same dimensions; the resistance of the mica was sixty times that of the paraffin paper. The hygrometer at the time indicated 30 per cent of moisture. Two strips of mica from the same specimens were prepared; the length of each was 27^{cm} the breadth 2^{cm}. Both were heated till their edges had become somewhat white, and on the following day their relative resistances were determined; these turned out to be nearly as 1 to 2. Knowing that mica when heated gives off traces of water and fluorhydric acid, a piece of this mica was heated in a Bunsen flame till its structure was destroyed, and on the following day, having been provided with a tin-foil armature, it remained for twenty minutes in contact with a Leyden jar charged to a potential of 12,000 volts. It was then removed and presented to an electroscope capable of indicating 100 volts, but failed to show any charge.

In the case of all the substances that thus far have been mentioned except two, it was found that when they were connected with the Leyden jar, that within at least fifteen minutes the

part farthest from the jar had assumed its potential, provided that no electricity was conducted off from it. This is not true of the substances that follow; their case is similar to that of rods conducting heat and slowly attaining the stationary condition.

Jade, gutta percha, black sealing wax.—There was placed at my disposal a fine bar of jade, 30^{cm} long with a square cross section of 12^{mm}. This was simply washed in water and sun-dried. Afterwards it was exposed to 12,000 volts for fifteen minutes. The electricity had traversed its whole length with a diminishing potential, that of the farther end being only 600 volts. This would have been much more than enough to have furnished electrometer strokes, but the rate of travel and the rate of delivery was so slow, that the electrometer was not affected. The following experiment was then made with the jade, and also later, with black sealing-wax and gutta percha. The end of the jade in contact with the Leyden jar had of course a tin-foil armature to facilitate conduction from the jar to the surface of the jade; at a distance of two centimeters from this armature the jade was wrapt with a strip of tin-foil, and this was brought into metallic connection with the electrometer placed at some distance. This arrangement assumes that the electricity will leave the Leyden jar, traverse two centimeters of naked jade, and then reach the electrometer by a connecting wire, and that no electricity will pass through the air by convection, and reach the movable conducting strip of foil and hence the electrometer. This supposition appeared to be practically justified by repeated experiments, where the knob of the Leyden jar retained its short distance from the movable armature, but was disconnected from the fixed terminal armature of the jade. I repeatedly watched for ten minutes at a time without finding that the disconnected jar produced any effect at all on the electrometer. This fact makes it possible to study cases which otherwise would offer difficulty. Using two centimeters of naked jade in this way, the electrometer furnished strokes needing ten seconds. Using four centimeters, the time of the first stroke was not 20 seconds but 47 seconds, the next following stroke needing 54 seconds, indicating the polarization usually observed in cases of surface conduction in connection with high resistance. Gutta percha and black sealing wax were now treated in exactly the same way; the movable armature being at 4^{cm}; they both refused to affect the electrometer, but with a distance of 2^{cm} the times needed for electrometer strokes were as follows:

	Gutta percha.	Sealing wax.
1st stroke	1′ 20″	2′ 2″
2d "	2′ 9″	5′
3d "	2′ 25″	no stroke.

On this day there was 30 per cent of moisture in the air.

In all the cases thus far examined the substances in question conducted sufficiently well to affect the electrometer arranged with a medium sensitiveness, but there were other insulators having still higher resistances, at least in dry weather.

Ebonite.—One of the most interesting of these is ebonite or hard rubber. It being very doubtful according to my previous experiments whether ebonite conducted electricity at all in dry weather, a strip of this material, 40^{cm} long and 1·5^{cm} broad, was provided with tin-foil armatures and then tested with the Bohnenberger electroscope for accidental charges, and afterwards connected for half an hour with a jar charged positively to 12,000 volts. It was then removed from the jar, the tin-foil discharged, and passed over the Bohnenberger electroscope. It was found to be *negatively* charged for about 17^{cm} from the jar end, the potential being a little under 110 volts, and gradually rising near the jar end, probably not much above 200 volts. This negative charge, I take it, is probably due to a separation of the ions, owing to the prolonged inductive action of the strong field. The final result is, that if the ebonite conducted at all in the regular way, such conduction was masked by the inductive effects.

Gutta percha.—Exactly the same experiment was made with a similar strip of gutta percha: it showed a charge of positive electricity that extended 16^{cm} from the jar-end of the strip; beyond this the electrification was negative, with a potential of from 100 to 200 volts. There seemed to be a neutral zone dividing the two opposite electrifications.

Amber.—The amber was 3^{cm} in length; one-half of it was wrapt in tin-foil fastened down by thread. Being supported by *insulating* silk thread, it was left for half an hour in contact with the knob of a Leyden jar charged positively to 12,000 volts. On removal and discharge of the foil armature, it was found charged positively, with a potential of 300 or 400 volts.

Rosin.—A piece of freshly cut rosin of the same dimensions and treated in the same way, became negatively electrified. Other experiments given below tend to show, that taking dry and damp weather together, plain rosin is the best insulator that was examined.

Insulating silk thread.—Ordinary thick white sewing silk was passed through a bath of one part of gutta percha melted

with three of rosin. Four centimeters of this was treated as above and became feebly *negatively* electrified, with a potential of about 200 volts. The temperature of this bath is rather high, and one composed of wax and rosin probably would answer all practical purposes.

Is the conduction of electricity by glass entirely on the surface, or does the electricity penetrate a little below the surface?—One experiment bearing on this question is here given: a sealed tube of soft German glass conducted quite well; a portion of it was heated till it melted black sealing wax, and in this way a few centimeters of it were coated with the wax, but when it was cold it conducted about the same as before. An application of boiled linseed oil produced no effect on its conducting power; finally, a few centimeters of the surface were ground away on a stone, but after washing, drying and the application of heat, it conducted just as before.

Experiments in damp weather.—The results of a few experiments on the effects produced by dampness of the air on the resisting power of certain insulators may be of interest, and some are here given.

Ebonite.—Hygrometer at 78°; a piece of the same sample previously mentioned was used; the distance from armature to armature was 17^{mm}; the breadth 13^{mm}, thickness 2^{mm}; it had been exposed to the air for several days. Employing 110 volts at first, it conducted quite well, its resistance being about 5000 megohms. It was then warmed, and while cooling showed a resistance as high as 1,200,000 megohms. In three minutes this fell to 15,000 megohms and then remained constant. Two hours later, the same figure was obtained.

Gutta percha of the same dimensions with the ebonite, without being warmed or dried in any way, had a resistance of 12,000 megohms.

Rosin, with armatures of tin-foil, the distance between them being only 9^{mm}, had a resistance of 1,500,000 megohms. It had been exposed to the damp air for days, and was not warmed or dried. These experiments were made on the same day, but on the following day when the air was somewhat drier, the hygrometer standing at 65°, the resistance of the ebonite was 340,000 and that of the gutta percha 440,000 megohms. The resistance of the rosin was too great to be measured without altering the distance of the plate P, which at the moment was undesirable. Freshly cut natural beeswax also appears to be a good insulator in damp weather. A few days later, the hygrometer standing at 60°, the resistance of the ebonite was again measured and turned out to be 1,100,000 megohms. It had in the meanwhile been exposed to the air

which had been damp. Wishing to improve the resisting power of ebonite against moisture, I painted a similar piece with boiled linseed oil, and allowed it to dry for two weeks. It was not improved as shown by my electrometer, and to avoid all uncertainty, I requested Mr. H. C. Parker to measure its resistance by the "direct deflection method" with a galvanometer; it turned out to be only 5300 megohms. It was then gently heated by a spirit lamp and while warm measured; the resistance had been raised to 90,000 megohms; it fell at first quite rapidly, and afterwards slowly, finally reaching, in four minutes, 6000 megohms. It was then heated to a temperature of 100° C. for four hours, and after free exposure to the air for three days, it was found that its resistance had been increased fifteen fold, the hygrometer standing at 54° when it was measured.

One more experiment may be given; on a somewhat damp day the hygrometer stood at 56°, the thermometer at 80° F.; pieces of mica and thin ground glass were prepared with metallic armatures; the pieces were 13^{mm} broad and the distance from armature to armature was 55^{mm}. The resistance of the glass was found to be nearly one thousand megohms, that of the mica 50,000 megohms.

In the preliminary measurements that have been detailed in this article, it has been assumed that during the transit of the electricity there is practically no loss by convection nor by leakage in the electrometer, so that the time consumed by a given charge in traversing a conductor and charging the electrometer to a given potential, would be directly proportional to the resistance of the conductor, and the few experiments that I have been able to make seem to justify this conclusion, but my set of high resistances was not completed in time to give it a rigorous examination. In dry weather the Leyden jar lost only two-thirds of its charge in twelve hours, although its necessary construction was far less favorable for insulation than was the case with all of the other arrangements.

The measurements given in this article were made with the help of certain standard units that I have recently constructed on a new plan. A considerable number were made, the resistance in each case not exceeding 5000 megohms. These were measured separately by Mr. H. C. Parker with a galvanometer and the "direct deflection method." Afterwards, they were joined together, and furnished suitable standards.

It may finally be remarked that almost all of the experiments described in this article are quite easy of execution, and many of them are well adapted for class illustrations.

June 18th, 1900.

ART. XXIX. — *On two new Occurrences of Corundum in North Carolina;* by JOSEPH HYDE PRATT.

WHERE formerly corundum was supposed to be rare in its occurrence and to be found in quantity only in the basic magnesian rocks, it is now known to occur in various types of rocks and in quantity, in syenites, gneisses and schists. Many new occurrences have been discovered during the past few years, some of which give indications of being of considerable economic importance, while others are only of scientific value. In the present paper two new occurrences are to be described, that have been observed in North Carolina, one in an amphibole-schist and the other in a quartz-schist.

Corundum in Amphibole-Schist.

At the Sheffield mine in Cowee township, Macon County, North Carolina, corundum has been mined in a saprolitic rock at various times for a number of years. While sinking a shaft eight feet square to penetrate the depth of the corundum-bearing saprolite, the solid unaltered rock was encountered. The shaft was 87 feet deep and showed the following sequence downward. The first 12 feet was through the saprolitic rock, in which there were seams, a few inches wide, of kaolin; the next two feet were corundum-bearing; from 14 to 28 feet the same saprolite was encountered and then another two feet that was corundum-bearing, followed by another ten feet of the saprolite and two more feet of the corundum-bearing rock; from 42 to 65 feet the rock began to be less decomposed and from 63 to 66 feet another seam that was corundum-bearing was encountered. From this point the rock became more and more solid, until at 77 feet the fresh rock was encountered. These various seams in the rock are very pronounced and are dipping 30° toward the west near the top, but become nearly horizontal nearer the bottom of the shaft. The seams of decomposed feldspar observed near the top of the shaft become less and less kaolinized downward, until in the solid rock the seams are of a pure plagioclase feldspar. In the hard rock exposed there are two seams of corundum similar to those above, although in the fresh rock the corundum seams are not as pronounced as in the saprolitic rock. There is often considerable of the feldspar bordering the seams of corundum. The general trend of the rock is about N. 5–10° E.

From what could be seen of the solid and the saprolitic rocks the corundum occurs in seams a few feet in width at intervals in the rock, and while the corundum may be ten or more per cent in these veins, its percentage in the rock, that it would be necessary to mine, would not probably be over three or four. The actual width of the dike is not known, but the saprolitic

rock has been cut across for nearly 100 feet in a direction about at right angles to the strike.

The fresh rock at the bottom of the shaft is somewhat varied in appearance and while it all does not show any definite gneissoid structure, the more finely divided portions are distinctly so. There are streaks, a few inches thick in the rock, that are composed almost wholly of a plagioclase feldspar. Some portions of the rock are decidedly porphoritic and contain phenocrysts of a light gray amphibole, a centimeter in diameter, in a groundmass of feldspar. A large part of the rock is made up, however, of small roughly-outlined prismatic crystals of an amphibole, probably hornblende, and irregular fragments of plagioclase feldspar. The hornblende is almost black in color but in thin splinters it has a bronze luster and a deep resinous color. Biotite of a deep brown color occurs sparingly, and a pink garnet is rather abundant. It is this part of the rock that is of a gneissoid structure and in which the corundum occurs. The corundum is of a light to a purplish pink color and in nodules up to two or three centimeters in diameter. There are some streaks in the rock that are very highly garnetiferous, composed essentially of the garnet and plagioclase feldspar, or of the garnet and biotite. Chalcopyrite occurs very sparingly in these portions of the rock. Small particles of graphite have been observed in the coarsely crystallized portions.

Prof. L. V. Pirsson has kindly made a microscopical examination of this rock, the results of which are embodied in the following paragraphs.

In thin section the microscope disclosed the minerals, hornblende, plagioclase feldspar, garnet, biotite, muscovite, staurolite and rutile. Hornblende is the most common, forming about two-fifths of the section, while of the remainder, plagioclase and garnet occur in about equal quantities and the others in comparatively insignificant amount.

"The hornblende is formless but tends to irregular columns almost invariably extended in the plane of schistosity; it has very rarely a somewhat stringy tendency in its cleavage but is usually homogeneous in broad plates. Its color is a clear olive-brown and it is somewhat pleochroic but not strongly so. It is everywhere dotted by the small grains of garnet, which rarely show good crystal form. The garnet occurs associated also with the plagioclase."

"The plagioclase occurs twinned according to the albite law only. In sections perpendicular to 010, the lamellæ show extinctions as great as 30° and the plagioclase is therefore rich in lime and as basic as labradorite, which it probably is. It shows strong evidence of shearing movement in the rock; it is

often broken, exhibits rolling extinctions and the albite lamellæ are curved and bent. It runs along the planes of schistosity between the feldspars and forms a mosaic of angular broken grains."

"Staurolite was found in rather broad irregular grains, and the rutile in small irregular grains and well crystallized prisms."

Prof. Pirsson has indicated that the character and structure of this rock, composed chiefly of amphibole, labradorite and garnet, suggests most strongly that it is a metamorphosed igneous rock of the gabbroid family. During metamorphism, the augite of the gabbro would be converted into the brown hornblende and any iron ore that was present would be taken up by the hornblende and garnet. The rutile would have resulted from the titanic acid that is a regular component of the iron ores in these gabbro or diabase rocks. Staurolite is rather naturally expected, as it is usually a mineral of metamorphism, and its natural home is in the schistose rocks. The feldspar has suffered the least (except the corundum) chemically and shows only the shearing of dynamic processes.

The corundum does not occur in crystals but in small fragments and in elongated nodules, which are cracked and seamed, and appear to have been drawn out by the shearing processes. The general character and shape of the corundums would indicate that they were original constituents of the igneous rock and were not formed during its metamorphism.

The exact classification of this rock is not easy, but it will probably be nearer correct to bring it under the head of an amphibole-schist.

Corundum in Quartz-Schist.

In the crystalline rocks of the southwestern part of North Carolina and the northeastern part of Georgia an interesting occurrence has recently been observed, namely that portions or bands of these are corundum-bearing. These corundum-bearing bands are first encountered on the head waters of Tallulah river, in the northern part of Rabun County, Georgia, and can be followed in a northeasterly direction to the Yellow Mountain in Clay County, North Carolina. They are near the top of the Blue Ridge, at an elevation of from 3000 to 4000 feet.

The composition of these rocks vary from those that are a normal gneiss to those that contain no feldspar and can best be described as quartz-schist, composed of biotite mica and quartz. Some portions of the rock are rich in garnet, while others are almost entirely free from this mineral, and occasionally there are small bands of white quartz. They are distinctly laminated and are frequently intersected by granitic dikes, some of which are coarsely crystallized and of a pegmatitic character, that are often parallel with the beddings of the schists, although many

of them are cutting irregularly through them. Where these dikes are parallel to the bedding of the schists, the laminated structure of the latter is more apparent. The general strike of these crystalline rocks is N.E.–S.W. and with a dip of about 30° to the N.W.

Portions, or bands, of these schists are corundum-bearing, but they are irregularly defined and gradually merge into the normal rock. They have a similar relation to the normal schists that the garnet-bearing bands of a gneiss have to the normal gneiss in which they occur. They are not veins in any sense of the word, but are simply portions of the same mass of crystalline rocks in which corundum occurs as a constituent of the rock. These bands vary in width from a foot or two to 12 or 15 feet, but in these wider ones the corundum-bearing portion is not continuous but is intercepted by streaks of barren rock and granitic dikes.

These bands can be traced for a distance of five or six miles in a N.E.–S.W. direction, sometimes outcropping continuously for nearly a mile. There are at least two of these corundum-bearing bands which are parallel to each other and about two miles apart. The only variation that has been observed in them is the percentage of corundum and garnet, otherwise they are identical. The percentage of corundum is never high, and from determinations made on samples from various parts of the deposits, it varies from two to five per cent.

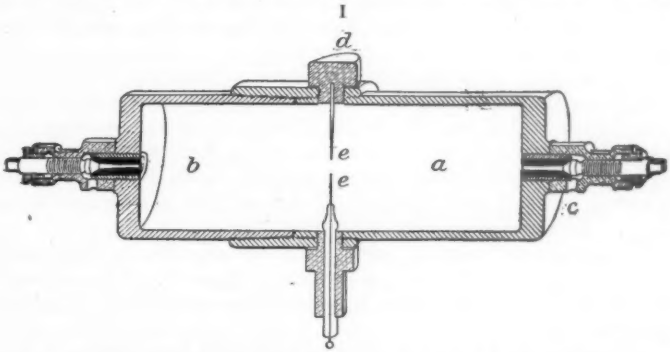
The corundum occurs for the most part in small particles and fragments that have no definite shape and are of a gray, white, and bluish-white color to almost colorless. It is also in crystals from minute ones to some that were observed two and a half inches long and about one-half an inch in diameter, which are usually fairly well developed in the prismatic zone.

It is probable that these schists are the result of the metamorphism of sandstones and shales formed from alluvial deposits of many thousand feet in thickness, that were formerly the bed of the ocean. By lateral compression these have been folded and raised into the mountain ranges of this section. That these were much higher than at the present time is very evident from the granitic dikes that are of deep-seated origin. By decomposition and erosion the mountains have been worn down to their present condition, thus exposing the schists in contact with granitic dikes which have aided in their thorough metamorphism. The shales were rich in alumina which not improbably was in the form of bauxite, and during their metamorphism the excess of the alumina crystallized out as corundum. This mineral has crystallized out along the planes of lamination so that during the subsequent weathering of the rock the corundum has been left in knotty nodules, studding the surface of the rock, giving it the appearance of containing a high percentage.

ART. XXX.—*On the Products of the Explosion of Acetylene, and of Mixtures of Acetylene and Nitrogen;* by W. G. MIXTER. Second Paper.

[Contributions from the Sheffield Laboratory of Yale University.]

THE bomb described in the first paper* was again used in the work unless otherwise stated. The figure of it is here reproduced (fig. 1) for convenience. The acetylene gas for the experiments was made by thrusting lumps of calcium carbide through the tubulure of a glass gas holder previously filled with water. The gas was dried as before by passing it through



a cylinder containing a kilo of small sticks of caustic potash. The determinations of acetylene were made as follows: The gas to be tested was passed into a eudiometer through a stop cock at the top of it. The acetylene was absorbed by an ammoniacal solution of cuprous chloride and the ammonia was finally washed out with water. The temperature and pressure of the gas remaining after the absorption of acetylene was made the same as before. This method is applicable only in absence of oxygen and carbonic oxide. The latter will be present when the acetylene exploded was mixed with water vapor or oxygen. Repeated tests for carbonic oxide failed to show the presence of that gas in the products of the acetylene exploded.

Experiment 36.—Gas, 99 per cent of acetylene; pressure, 2 atmospheres. The explosion was prompt. It extended through a brass tube $1\frac{1}{2}^{mm}$ in diameter and 1 meter in length to the manometer. The determinations of acetylene in the residual gas gave 4, 4·3 and 3·7 per cent.

* This Journal, vol. ix, 5.

Experiment 37.—Gas, 98 per cent of acetylene; pressure, 1289^{mm}; temperature, 12°; electrodes, 2^{mm} apart. The gas was sparked repeatedly for several seconds. Carbon separated about the electrodes, but there was no explosion and the gas after the sparking was found to contain 98 per cent of acetylene.

Experiment 38.—Gas, 98 per cent of acetylene; pressure, 1312^{mm}; temperature, 15°. The electrodes were 3^{mm} apart. There was no explosion and no change in pressure during the sparking.

Experiment 39.—Gas, 96 per cent of acetylene; pressure, 1472^{mm}; temperature, 14°. The pressure after the explosion at 14° was 1425^{mm}, showing a condensation of 3·2 per cent. Two determinations of acetylene in the residual gas gave 3·4 and 3·3 per cent.

Experiment 40.—Gas, 98 per cent of acetylene; pressure, 5·1 atmospheres, which was the same after the explosion when the bomb had attained the temperature of the water in the tank in which it was immersed. The gas tested was taken before the pressure in the bomb had fallen below 4 atmospheres. Three tests yielded 2·3, 2·4 and 2·4 per cent of acetylene. The carbon nearly filled the bomb.

The nitrogen used in subsequent experiments was prepared from sodium nitrite and ammonium chloride. The mixtures of acetylene and nitrogen were dried as described by caustic potash.

Experiment 41.—Gas, 89·3 per cent of acetylene and 10·7 per cent of nitrogen; pressure 3·2 atmospheres before and after the explosion. Two estimations of acetylene in the gas after the explosion gave 1·4 and 1·4 per cent. In order to determine the amount of hydrocyanic acid, the gases (933^{cc} reduced to 0° and 760^{mm}) from the bomb were passed slowly through a dilute solution of pure potassium hydroxide. This solution was then titrated with a decinormal solution of silver nitrate, requiring 5·2^{cc} to produce a permanent precipitate of silver cyanide. This corresponds to 0·028 gram of hydrocyanic acid and 23^{cc} of the compound in the gaseous state. The bomb had a capacity of $1\frac{1}{10}$ liters, but for convenience the result may be given as the amount of hydrocyanic acid in a volume of 1 liter in the bomb. It was 0·083 gram and 63·3^{cc}. The potash solution after the titration was acidified with hydrochloric acid, boiled, cooled, then an excess of potash was added and the solution was again boiled. The escaping vapor was found to be free from ammonia. Nor was any found in another test similar in all respects except that the titration with silver nitrate was omitted.

Experiment 42.—Gas, 85 per cent of acetylene and 15 per cent of nitrogen; pressure, 3061^{mm}; temperature, 17·8°. The pressure after the explosion when the gas had cooled to 17°·8 was the same as before the explosion. Each of two tests for acetylene in the residual gas gave 0·25 per cent. The residual gas was passed slowly through an absorbing tube containing a dilute solution of potassium hydroxide until the pressure in the bomb had fallen to that of the atmosphere; 20^{cc} of a decinormal solution of silver nitrate were used in titrating the solution of potassium hydroxide. Next 10^{cc} of a concentrated solution of potassium hydroxide were poured into the bomb to absorb the hydrocyanic acid remaining in it. The mixture of carbon and potassium hydroxide was thoroughly shaken and then washed on a filter. The filtrate required 14·4^{cc} of a decinormal solution of silver nitrate, making the total amount of the solution of silver used 34·4^{cc}, corresponding to 0·1858 gram of hydrocyanic acid, or 0·1688 gram and 139·6^{cc} (at 0° and 760^{mm}) per liter in the bomb.

Experiment 43.—Gas, 76·6 per cent of acetylene and 23·4 per cent of nitrogen; pressure 3818^{mm} at 14·8°. 1·7 per cent of acetylene was found in the first portions of gas drawn from the bomb and 2·5 per cent when the pressure was little more than that of the atmosphere. The attempt to estimate the hydrocyanic acid remaining in the bomb was unsuccessful. An alcoholic solution of potash was used, as this wets the finely divided carbon better than water. The filtered solution became turbid on adding silver nitrate and the titration was so unsatisfactory that the result was rejected. The solution of potassium hydroxide used to absorb the gas drawn from the bomb required in titrating 32·3^{cc} of a decinormal solution of silver nitrate corresponding to 0·1747 gram of hydrocyanic acid. As $\frac{4}{5}$ths of the gas in the bomb were taken for this determination we may assume that $0{\cdot}1747 \times \frac{5}{4} = 0{\cdot}2187$ gram was the total amount of hydrocyanic acid in the gas in the bomb and not condensed on the carbon. This result calculated for a volume of 1 liter gives 0·200 gram and 165^{cc} (at 0° and 760^{mm}) of hydrocyanic acid. The gas after the explosion was alkaline to litmus and the solution of potassium hydroxide gave off ammonia on warming.

Experiment 44.—Gas, 87 per cent of acetylene and 13 per cent of nitrogen. The nitrogen was collected over an alkaline solution of pyrogallic acid to absorb traces of oxygen, and then was mixed with the acetylene over a solution of ferrous sulphate in order to free the gases from possible traces of ammonia. As the bomb leaked after the explosion, it was only possible to determine approximately the ratio between the

quantities of hydrocyanic acid and ammonia formed. The potassium hydroxide solution through which the gaseous products of the explosion were passed required 5^{cc} of a decinormal solution of silver nitrate to form a permanent precipitate of silver cyanide, 5^{cc} more of the silver solution were added in order to remove the cyanides from the solution, and the precipitated silver cyanide was filtered off. The filtrate was then cautiously distilled into hydrochloric acid. The acid solution was finally evaporated to dryness. The residue was 0·0035 gram of ammonium chloride, equivalent to 0·001 gram of ammonia. As 5^{cc} of the silver solution correspond to 0·027 gram of hydrocyanic acid, the ratio between the ammonia and hydrocyanic acid formed is apparent.

In order to determine whether or not the gas after the explosion contained cyanogen, the alkaline solution from which ammonia was distilled was acidified with hydrochloric acid, boiled, then made alkaline with potassium hydroxide. This last solution gave when distilled no ammonia. If cyanogen had been present in the gas, there would have been formed in the solution of potassium hydroxide through which the gaseous products of the explosion were passed, cyanide and cyanate. The latter salt, as is well known, yields an ammonium salt when treated with an acid.

Experiment 45.—The mixture of acetylene and nitrogen containing 28 per cent of the latter gas was allowed to stand 24 hours over a solution of ferrous sulphate mixed with ferrous hydroxide in order to free the gas from oxygen and possible traces of ammonia. The pressure of the gas before the explosion was 3781^{mm}, a little less than 5 atmospheres, at 6·4°. The gas drawn from the bomb after the explosion when the pressure was nearly 5 atmospheres contained 3·2 per cent of acetylene, and that portion drawn at 1·3 atmospheres contained 5·6. The hydrocyanic acid estimated as in previous experiments was found to be ·170 gram and 140^{cc} per liter in the bomb. The ammonia found in the same volume of gaseous products was ·0047 gram. Here we have a ratio of 1 of ammonia to 36 of hydrocyanic acid in the products of the explosion.

Experiment 46.—The mixture of acetylene and nitrogen containing 10 per cent of the latter was purified as in the previous experiment. It was sparked when at a pressure of 3856^{mm}. The first portion of the gas drawn from the bomb was found to contain 1·7 per cent of acetylene and that taken at a pressure of 2 atmospheres 2·2 per cent. The hydrocyanic acid found corresponded to 0·145 gram and 120^{cc} per liter in the bomb. Likewise the ammonia was 0·0046 gram. Here the ratio of the ammonia to the hydrocyanic acid is 1 to 30.

Experiment 47.—Two liters of a dried mixture of acetylene and nitrogen containing 10 per cent of the latter gas were passed through a combustion tube which was heated to a temperature sufficient to decompose the acetylene. The gaseous products were passed through a solution of potassium hydroxide to absorb hydrocyanic acid. But not a trace was found by the prussian blue reaction. The same result was obtained a second time.

Experiment 48.—A mixture of acetylene and air was exploded in an open liter jar. Much soot separated and the flame passed slowly into the jar. No hydrocyanic acid was detected in the products, and none in several repetitions of the experiment.

Experiment 49.—The sides of a jar were moistened with strong ammonia water and the air in the jar was mostly displaced by acetylene. On applying a flame to the mouth of the jar there was a slight puff and an abundant separation of soot in the jar. Hydrocyanic acid was found in the products of four experiments, and it was also formed rather abundantly when illuminating gas was substituted for acetylene.

Experiment 50.—Acetylene was passed through concentrated ammonia water, then through a tube heated to dull redness by one burner. Hydrocyanic acid was formed.

The experiments 19 to 28 described in the first paper (loc. cit.) were made in U-tubes having a diameter of 17 to 20^{mm}. The residual gas contained much acetylene and the amount of condensation products was considerable. In order to learn if the character of the products is due to the expansion of the gas when exploded, the next two tests were made in an iron U-tube 7·5^{cm} in diameter. To the ends of this tube were attached the parts *a* and *b* of the iron bomb (fig. 1, p. 299). The apparatus was designed for observing the effect of explosions under the same conditions as in the bomb except that the gas was not subjected to constant volume. About 50 kilos of mercury were required in the apparatus and 1800^{cc} of dry acetylene measured at atmospheric pressure were used. The U-tube when charged for an explosion was hung in a tank of water in order to cool it quickly after an explosion. When acetylene is fired in such a U-tube the products cool more rapidly than in the bomb.

Experiment 51.—Gas, 99 per cent of acetylene; pressure, 2060^{mm} at 18°. The electrodes were 2^{mm} apart. The explosion was prompt and the pressure after it was 2097^{mm} at 18°. Two determinations of acetylene in the gas after explosion gave 3 per cent.

Experiment 52.—Gas, 99 per cent of acetylene; pressure, 2300^{mm}. The electrodes were 4^{mm} apart. Two estimations of acetylene in the gas taken at 3 atmospheres gave each 1·5 per cent, and when the pressure in the apparatus had fallen nearly to that of the atmosphere the portions tested were found to contain 1·9 and 1·8 per cent of acetylene.

The next two experiments were made in the iron U-tube in order to find the effect that the expansion accompanying the explosion has on the formation of hydrocyanic acid. The mixtures of acetylene and nitrogen were kept for a day over a solution of ferrous sulphate in which was suspended ferrous hydroxide.

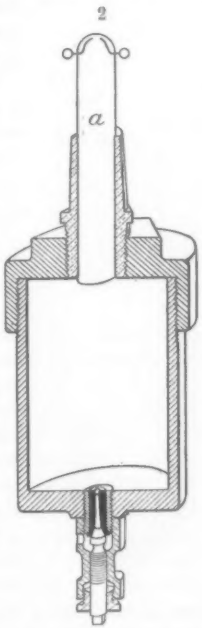
Experiment 53.—About 1·5 liters, measured at atmospheric pressure, of gas containing 15 per cent of nitrogen were used. The mixture was sparked when under a pressure of 2·5 atmospheres. The residual gas contained 1·25 per cent of acetylene. 800^{cc} of it were passed through a solution of potassium hydroxide. This was then titrated with a decinormal solution of silver nitrate, requiring 0·4^{cc} to produce a permanent precipitate, a result not indicating satisfactorily the presence of cyanides.

Experiment 54.—The mixture contained 13·5 per cent of nitrogen. Two liters of gas were taken and subjected to a pressure of 2·5 atmospheres. The explosion was prompt. The estimation of acetylene in the residual gas was not satisfactory but it showed there was less than 3 per cent present. 1000^{cc} of the gas left by the explosion were passed slowly through a solution of potassium hydroxide. One drop of a decinormal solution of silver nitrate gave to the solution a permanent brown precipitate. Next, 200^{cc} of the gas were passed through a solution of potassium hydroxide, made from the metal. Finally a few drops of a solution of ferrous ferric sulphate were added and the mixture was warmed, cooled, and made acid with hydrochloric acid. No prussian blue was formed, a proof that no hydrocyanic acid had been formed.

These results in the iron U-tube prove conclusively that the large amounts of acetylene and condensation products in the earlier experiments in glass tubes are not attributable to expansion at the time of the explosion.

In order to learn whether the peculiar explosive wave of experiments 27 and 28 of the first paper can be transmitted to gas in a larger vessel and there produce the same effect, the next two experiments were made in the apparatus shown in fig. 2. The tube *a* is glass and has a diameter of 18^{mm}.

Experiment 55.—Gas, 98 per cent of acetylene; pressure, 2·6 atmospheres. The electrodes were 3^{mm} apart and less than 1^{mm} from the glass. The sparking at first produced a filament of carbon between the electrodes. A much stronger secondary current was then applied and after some seconds there was a sudden glow and carbon was deposited abundantly in a length of 10^{cm} of the tube. The explosion did not extend to the gas in the bomb. The residual gas contained 97·5 per cent of acetylene.



Experiment 56.—Gas, 98 per cent of acetylene; pressure, 2316^{mm} (3·3 atmospheres) at 15°. The electrodes were 4^{mm} apart and 3^{mm} from the glass. A momentary closing of the primary circuit produced an explosion. The pressure when the gas had cooled to 15° was the same as before the explosion. There were in the glass tube brilliant black rings of carbon separated by spaces less densely coated. Two estimations of acetylene in the residual gas taken at 2·7 to 3·3 atmospheres gave each 1·3 per cent, and two portions taken when the gas in the bomb was at 1·5 atmospheres and less gave 1·7 and 1·6 per cent.

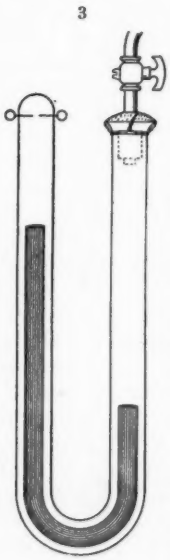
If the peculiar explosive wave started in the tube extended to the gas in bomb it caused almost complete decomposition of the acetylene.

As the acetylene used thus far in the work was not free from traces of water, the following experiments were carried out in U-tubes such as shown in fig. 3 filled with gas containing 98·8 per cent of acetylene. Some phosphorus pentoxide was placed in the tube and also a clean piece of phosphorus; the latter was to remove traces of oxygen.

Experiment 57.—The volume of the gas diminished slowly on standing indicating an absorption, but there was no appearance of a tarry product. Five days after the tube was filled, the gas, measuring 60^{cc}, was condensed to 19^{cc} and then sparked. The explosion was prompt and violent. The condensation was 4 per cent and the acetylene in the residual gas was 4 per cent of the gas taken.

The tube was filled again with acetylene and the phosphorus pentoxide was made to coat the upper part of it. A piece of phosphorus was placed in the gas. The volume

diminished slowly and a reddish liquid appeared. A little water was introduced in order to find if phosphoric acid will condense acetylene. The change if any was slight in two days. Owing to an accident the experiment was not completed, but the absorption observed suggests doubt as to the value of phosphorus pentoxide as a drying agent for acetylene. In the remaining experiments no such absorption was observed.



Experiment 58.—After 8 days the phosphorus was removed and the pressure increased to 3·3 atmospheres and the gas was then sparked. The condensation was 8 per cent and the acetylene remaining was 8 per cent.

Experiment 59.—A smaller quantity of phosphorus pentoxide was used than before. However, some remained unaltered and after 8 days the pressure was made 3 atmospheres and the gas was sparked. The explosion was prompt and apparently as violent as any in the glass U-tubes. 6 per cent of the gas had formed condensation products and the acetylene in the residual gas was 24 per cent of that taken.

Experiment 60.—The acetylene stood over a solution of calcium hydroxide 3 days before it was put into the U-tube. The phosphorus pentoxide used filled a tube 2^{cm} long and 1^{cm} wide used to hold it. The phosphorus was also placed in a short tube. When the apparatus was filled the volume of the gas was noted and it did not change appreciably in the two weeks the gas was left to dry and to give up traces of oxygen. The gas, 57^{cc}, was then condensed to 19^{cc} and sparked by closing the primary for an instant. The explosion was prompt and violent. The condensation was 5 per cent and the acetylene in the residual gas was 21 per cent of the gas taken for the test.

The results obtained with dry acetylene indicate that water is not essential to the explosion of the gas, and that the wide variations noted in the first paper in the products of explosions in glass tubes are not to be ascribed to the presence of water.

The following table gives the number of cubic centimeters of acetylene and hydrocyanic acid per liter of gas in the bomb after explosion.

No. of Exp.	Pressure in atmospheres.	Per cent of C_2H_2 in gas after explosion.	C. C. at 0° and 760^{mm} of C_2H_2 per l. in bomb.	C. C. at 0° and 760^{mm} of H C N per l. in bomb.
29	3	4	120	
30	3	4·1	123	
36	2	4·	80	
39	1·95	3·3	66	
40	5·1	2·4	122	
41	3·2 N 10·7 %	1·4	45	63
42	4· N 15 "	0·25	10	140
43	5· N 23 "	2·1	105	165
45	5· N 28 "	4·4	220	140
46	5· 10	2·	100	120
51 in U-tube	2·7	3·	81	
52 "	3·	1·7	51	
53 "	2·5 N 15 "	1·3	32	0
54 "	2·5 13 "	Not estimated.		0

The above are all of the results obtained with the bomb, fig. 1, and with the iron U-tube having the same diameter as the bomb, excepting experiments 31 to 35 described in the first paper. The amounts of acetylene and hydrocyanic acid found in the residual gas drawn from the bomb do not include quite all of these compounds, as there was some condensation on the carbon. This is evident from the fact that gas taken at 4 or 5 atmospheres contained less acetylene than that taken at lower pressures. The above data derived from the experiments are not sufficient to yield the relation between the pressure and the quantity of acetylene in the residual products. It is obvious, however, that at the lowest pressure at which explosion will occur the total quantity of acetylene left in the bomb is much less than when the initial pressure is 3 or more atmospheres. The small amounts found in experiments 51, 52 and 53 show that a more rapid cooling in the large iron U-tube than occurs in the bomb does not increase the acetylene in the residual gas. This fact supports the view expressed in the first paper that the acetylene in the gas after explosion is not an undecomposed portion of the original gas.

There is, however, no question about the synthesis of hydrocyanic acid in the explosions of mixtures of acetylene and nitrogen in the bomb. But in the U-tube the nitrogen did not combine. In the former instances the molecules of nitrogen either acquired energy adequate for combination or were dissociated, while in the latter they remained in the inert condition characteristic of the element. The velocity of explosion

of acetylene is 1000 meters and higher per second,* and in the iron U-tube the expanding gas must move a column of mercury about 80^{cm} in length, that is, the pressure on 1$^{sq\ cm}$ must move one kilo of mercury. It is highly improbable that this mass is displaced materially before the explosion is completed. If this assumption be correct, the temperature at the instant of explosion is the same in the U-tube as in the bomb. In the former the expanding gas cools more rapidly than in the latter. In the bomb there is a sufficient number of collisions to impart to the molecules of nitrogen the energy adequate for combination or to dissociate them into atoms. In the U-tube the volume of the gas increases after the explosion and the collisions are fewer than in the bomb and the nitrogen does not combine. Thus we may conclude that, even at the temperature of exploding acetylene, a sufficient frequency of collisions is requisite to cause nitrogen to combine.

The amount of hydrocyanic acid remaining in the bomb does not appear to depend upon the proportion of nitrogen in the mixture exploded, for the result was the same with 15 per cent of nitrogen in the mixed gases at a pressure of 4 atmospheres as with 28 per cent at 5 atmospheres. It may be that a fixed quantity of hydrocyanic acid per unit of space remains when the products of the explosion cool and assume a state of equilibrium.

Acetylene and ammonia, as shown by experiments 49 and 50, yield hydrocyanic acid at a much lower temperature than is required to cause nitrogen to combine. It may be that ammonia is the first compound of nitrogen formed in the bomb, but the fact that a little ammonia is found in the products of an explosion is not conclusive, as this may have resulted from the decomposition of hydrocyanic acid. Dewar† passed a mixture of hydrogen and nitrogen through a carbon tube heated externally by an electric arc and obtained hydrocyanic acid. Here the conditions were similar to those in bomb, namely, carbon, hydrogen and nitrogen at a very high temperature. Dewar made no statement regarding the presence or absence of ammonia in the products of his experiment, and Berthellot‡ considered that ammonia played no part in the synthesis of hydrocyanic acid effected by sparking a mixture of acetylene and nitrogen. The results in the bomb indicate that less acetylene remains when nitrogen is present than when pure acetylene is exploded, but they are not conclusive. Berthellot (loc. cit.)

* Berthellot and Chatelier, Comptes Rendus, cxxix, 427; Ann. Chim. et Phys., xx, 15.

† Proc. Roy. Soc., xxix, 188, and xxx, 85.

‡ Comptes Rendus, lxvii, 1141.

observed that a mixture of acetylene and nitrogen diluted with hydrogen did not deposit carbon when sparked, and that all of the acetylene or nitrogen, an excess of one or the other being present, was removed by prolonged sparking of the mixed gases over a solution of caustic potash to remove the hydrocyanic acid. He considered that nitrogen united directly with acetylene and represented the reaction by the equation

$$C_2H_2 + N_2 = 2HCN.$$

As acetylene was not decomposed by the sparks, it must have combined directly with nitrogen. The reaction is of great interest, as it shows that the nitrogen molecules are rendered chemically active by conditions which do not dissociate endothermic acetylene.

Art. XXXI.—*Scapolite Rocks from Alaska;** by J. E. Spurr.

The following rocks containing scapolite as an essential constituent were collected by the writer in the summer of 1898, while making a geological reconnoissance in southwestern Alaska.

Andesine-oligoclase-scapolite-biotite rock.

This rock was found on the Yentna River (a branch of the Sushitna) some 12 or 15 miles above the junction with the Sushitna, where it forms large masses of uniform appearance, which are probably great dikes cutting an older rock. Specimens of this older rock, taken in different places, proved to be hornblende syenite and hornblende diorite. The scapolite rock is coarse-grained and granitoid in appearance, the bluish-gray of the scapolite suggesting quartz at first glance. Under the microscope the structure is hypidiomorphic granular, grading to panidiomorphic. The essential minerals are feldspar, scapolite, and biotite, abundant in the order of naming. The feldspars are mostly twinned according to the albite law, and one crystal examined by the Fouqué method showed on a section perpendicular to the negative bisectrix an angle of 70° between the plane of the optic axes and the albite twinning, proving it to be an andesine-oligoclase. The scapolite is both idiomorphic and hypidiomorphic, like the feldspar. Some sections are always dark, and give the dark cross of uniaxial minerals in convergent light. The cleavages, which are often broken, intersect at right angles and belong to the faces 100 and 010; another less perfect cleavage evidently belongs to the prism 110. The relief of the mineral is small, like quartz, while the double refraction is higher, giving a light-yellow color; it is optically negative. The biotite is fresh, and like the other minerals is idiomorphic or hypidiomorphic in habit; it contains grains of apatite. Small crystals of zircon, showing the prism and pyramid faces, are occasionally found.

Analysis of andesine-oligoclase-scapolite-biotite rock.

[Analyst, Dr. H. N. Stokes.]

	Per cent.		Per cent.
SiO_2	62·78	BaO	·04
TiO_2	·56	SrO	trace
CO_2	----	CaO	4·84
P_2O_5	·15	MgO	2·32
S	·02	K_2O	2·15
Cl	trace	Na_2O	4·11
Al_2O_3	17·16	Li_2O	trace
Fe_2O_3	1·96	H_2O at 100°	·24
FeO	2·31	H_2O at 110°	·88
MnO	·06		
		Total	99·58

* Published by permission of the Director of the U. S. Geological Survey.

The above analysis bears out the results of the optical investigations and throws some additional light on the probable variety of scapolite. The high percentage of silica in the rock and the low percentage of lime indicate that the scapolite is probably of the variety dipyre. The rock therefore presents some analogy to the so-called dipyre-diorite of the Norwegian geologists.

Microcline-scapolite rock.

This is from the same locality as the rock just described and is doubtless a variation produced by differentiation. In the outcrop it has the appearance of a vein, forming a distinct tongue of light-colored material between walls of mottled rock, which appear to be essentially the same as the scapolite rock previously described, but of finer grain. This finer-grained biotite-scapolite rock grades off distinctly into the coarser-grained lighter-colored vein, which is about two inches thick. Under the microscope the structure is very coarse and the constituent grains are intergrown. Among the minerals microcline prevails, with considerable scapolite, which is largely altered to calcite. The scapolite gives in the basal section uniform darkness and the interference cross; it has abundant irregular cleavages and cracking, and shows yellow of the first order as an interference color.

Quartz-scapolite porphyry.

A rock called quartz-scapolite porphyry, for want of a better name, comes from a point far distant from the rocks just described, being found on the Kuskokwim River at the mouth of the Holiknuk, where it occurs among the light-colored dikes which cut the Cretaceous shales and shaly limestones. Under the microscope the rock shows phenocrysts of quartz, which are of small size and are bounded chiefly by the dihexahedral planes, but sometimes have the prism sparingly developed and sometimes show the faces of pyramids of two orders; the edges are often frayed by magmatic resorption. There are frequent large idiomorphic phenocrysts of scapolite, more or less broken down by decomposition. These phenocrysts give a uniaxial figure in convergent light. The outlines of the crystals show that they are of the tetragonal system, and they are characterized by low single and double refraction; they are optically negative. There is good cleavage parallel to the two lateral pinacoids, while that parallel to the prism is present but not so well developed. Irregular fractures are common. The mineral has decomposed along the margins and cleavages, partly to calcite, but mainly to an opaque kaolinic substance

which is colored brown with iron oxide. There are abundant microscopic inclusions arranged in zones within the crystal. Judging from the paucity of calcite among the decomposition products and also from the apparent small single and double refraction of these scapolites, the mineral is probably a soda scapolite (marialite end of the series). By exception, some almost entirely altered phenocrysts now consist chiefly of calcite, but what remains seems to be scapolite, and the outlines of the phenocrysts corroborate this inference. These decomposed scapolites are probably lime scapolites, or meionites. A few small phenocrysts, mostly altered to calcite, muscovite, etc., seem to have been originally soda-lime feldspar. The groundmass is a fine-grained aggregate, consisting chiefly of quartz, orthoclase, and muscovite. In the fresher scapolite phenocrysts the cross sections are sometimes rectangles, but the favorite occurrence is in the form of a penetration twin of two such crystals along the composition plane 110; and the corners of the pinacoids whose faces constitute the rectangles are truncated by the prism. There are no true longitudinal sections in the slide, all being of small double refraction and having approximately the same orientation.

Occurrence of Scapolite Rocks elsewhere.

The scapolite rock from Norway in the vicinity of Oedegården has been described by Brögger and Reusch. This rock is essentially a mixture of scapolite and amphibole with accessory titanite, and was regarded by the describers as a facies of the gabbro (hyperite) in the neighborhood of veins of apatite which traverse the gabbro. The observers concluded, moreover, that the scapolite rock was formed by the alteration of the normal hyperite or gabbro, since they found remnants of diallage in the hornblende, as if the former were the original mineral, and of plagioclase in the aggregates of scapolite, as if the scapolite had formed from the plagioclase. The alteration, according to Brögger's view, was due to gaseous or pneumatolitic action.*

In Canada, also, granular rocks containing scapolite have been described from a number of localities.† In one of these rocks the principal constituents are pyroxene, hornblende, and scapolite, with accessory epidote, enstatite, pyrrhotite, and rutile, and the rock is classified as a scapolite diorite, it having a granular structure. Another rock is made up of an aggre-

*See Rosenbusch's Mikroscopische Physiographie der Massigen Gesteine, vol. i, p. 331.

† On some Canadian rocks containing scapolite, etc., by Frank D. Adams and Andrew C. Lawson: Canadian Rec. Sci.

gate of plagioclase, scapolite, and green hornblende, with accessory pyroxene, quartz, epidote, and pyrite, and this rock is termed a plagioclase-scapolite diorite. It is stated in the pamphlet referred to that "although the derivation of at least a part of the hornblende of these rocks from pyroxene is well-nigh certain, the derivation of the scapolite from plagioclase, which, as already stated, has been pretty clearly proved in the case of the Norwegian rocks, is not so evident in these similar rocks from Canada." Also, Dr. A. P. Coleman reports from Ontario a scapolite rock consisting of hornblende, plagioclase, and scapolite, in which the scapolite was evidently primary.*

Finally, scapolite rock occurs in the white limestone of New Jersey at many localities and in large amounts, the rock consisting in one locality of scapolite, hornblende, pyroxene, and sphene, and in another locality of the same minerals with the addition of a little plagioclase. These dikes are evidently igneous, and fumarolic or gaseous action has been suggested as taking part in their formation.†

In addition to these granular scapolite rocks, scapolite gneisses and amphibolites have been described from various places.‡

Origin and Classification of the Alaskan Scapolite Rocks.

In the locality on the Yentna River which has been described the main intrusive rock of the country was noted in the field to be a biotite granite, but of this, unfortunately, no specimen was retained. Dikes of quartz-feldspar rock or alaskite,§ which were found cutting the granite, have been carefully examined microscopically, and connected with this alaskite were rocks transitional into the granite, and quartz veins sometimes containing tourmaline. The specimen of scapolite rock was from a large mass forming bluffs 40 feet high, and seemed typical; it is certain that this rock occurs in notable quantity, but in just what proportion to the other dikes is not certain. All these dikes cut an ancient igneous rock, which was shown in one case to be a hornblende syenite and again a hornblende diorite.

In the second case which has been described, namely, the quartz-scapolite rock from the Kuskokwim River, the scapolite dikes were associated with a number of other siliceous dikes. Those which were examined microscopically, besides the scapolite porphyry, are an alaskite porphyry and a granite porphyry.

* See Zirkel's Lehrbuch der Petrographie, vol. ii, p. 783.

† F. L. Nason, Annual Report of the Geological Survey of New Jersey, 1890, p. 33.

‡ Zirkel, op. cit., vol. iii, p. 339.

§ See author's paper on Classification of Igneous Rocks according to Composition; Am. Geol., xxv, April, 1900, p. 210.

In both these cases the scapolite is regarded as original. There is no evidence of its derivation from feldspar, but rather in every case of contemporaneous formation. Certainly the mineral is not the product of weathering, for it is nearly always in a process of decomposition, showing itself as unstable under atmospheric conditions as are the feldspars. It is exceedingly probable, however, that in the formation of this, as in other occurrences of scapolite rock, gases have played an important part. The scapolites contain chlorine, otherwise they have essentially the composition of the soda-lime feldspars. The marialite scapolite corresponds to oligoclase, and the meionite scapolite to anorthite, with a series between like that of the feldspars, so that when scapolite is found instead of feldspar we may suppose chlorine gas to have been present at the time of the formation of the rock. This is, however, no good reason for considering the rock as of secondary origin, for in most igneous rocks the gases play some part in the formation and in many a very weighty part, the rocks nevertheless belonging to the class of original igneous rocks. The writer is inclined, therefore, to give the scapolite rocks a place among the primary igneous rocks wherever the scapolite shows evidence of having formed contemporaneously with the other rock minerals. In cases where it evidently is an alteration product from some other rock, the classification will of course be different.

In case classification is attempted, the scapolites might be considered, for the purposes of classification, as equivalent to the feldspars, when they occur in rocks where feldspar is present in an equal or greater amount. Thus the biotite-scapolite rock from the Yentna River might be called a biotite scapolite-belugite,* since the feldspar belongs to the andesine-oligoclase series, and the equally important scapolite seems to be of a variety containing much lime and corresponding to anorthite in the feldspar series. The scapolite-belugites might then be considered a group of the belugite family.

The porphyritic scapolite rock from the mouth of the Holiknuk on the Kuskokwim might be called a scapolite-adamellite porphyry, adamellite being the name adopted by Brögger for the quartz-bearing monzonites. In this case the scapolite appears to belong mainly to the soda end of the soda-lime series, and thus is the equivalent of oligoclase-andesine. The groundmass appearing to be mainly orthoclase, the feldspathic constituents (considering scapolite as such) would be on the whole intermediate between the granite and diorite families, or in the monzonite family. In this case the rock might be con-

* See writer in Am. Geol., xxv, April, 1900, p. 233.

sidered to belong to what might be called the scapolite-adamellites, which would be a group under the monzonite family where the scapolite partly takes the place of the feldspar.

It would probably be best, however, to separate the scapolite-feldspar rocks into a distinct class, and to give the groups characteristic names, the analogy with the feldspar rocks being expressed by writing in the tabulation each group laterally opposite the corresponding group of feldspar rocks. Thus the rock first described may be called yentnite, from the Yentna River, instead of scapolite-belugite, but it may be written opposite the belugite group; the type would then be a biotite yentnite. Similarly the quartz-scapolite porphyry from the Kuskokwim* River might be called kuskite, instead of scapolite-adamellite; the kuskite group of the scapolite-feldspar class of rocks could be written opposite the adamellite (or quartz-monzonite) group of feldspar rocks, and the type might be called a kuskite porphyry.

* Eskimo *Kuska*, derivation uncertain, *kwik*, genitive *kwim*, river.

ART. XXXII.—*On the Qualitative Separation of Nickel from Cobalt by the action of Ammonium Hydroxide on the Ferricyanides;* by PHILIP E. BROWNING and JOHN B. HARTWELL.

[Contributions from the Kent Chemical Laboratory of Yale University—XCVII.]

SOME years ago F. W. Clarke* suggested a method for the separation of nickel from cobalt depending upon the solvent action of ammonium hydroxide upon the precipitated ferricyanides. The method may best be described by quoting from the original article: "To the slightly acid solution containing the two metals, I first add an excess of ammonium chloride. This causes the cobalt precipitate, which otherwise would run through the filter, to fall in a denser state, and also of a much darker color, often nearly black. I then add the potassium ferricyanide until the precipitation is complete, and afterwards agitate strongly with a considerable excess of ammonia. Upon filtering, all the cobalt remains upon the filter, being recognized by the characteristic color of the precipitate, and the nickel is readily detected in the filtrate, by means of ammonium sulphide. If, upon filtering, the portion at first running through is turbid, it may be disregarded, or returned to the filter, that which filters through subsequently being almost invariably clear."

In making a study of this method we found two serious objections; first, the practical impossibility of obtaining a good filtration from the cobalt ferricyanide, even in the presence of the ammonium chloride, and, second, the large amount of sulphur thrown down when ammonium sulphide was added to the filtrate containing the nickel with the excess of ferricyanide.

Our first attempt was to secure, if possible, a complete separation of the precipitated cobalt ferricyanide and the dissolved nickel by filtration. This we were able to accomplish by the addition of a small amount of a solution of an aluminum salt to the original solution which held back the cobalt, and, as experiment showed, allowed the complete solvent action of the ammonium hydroxide upon the nickel salt. Amounts of nickel as small as 0·0001 grm. were detected, when mixed with the aluminum salt, by precipitating as ferricyanide, extracting with ammonium hydroxide, and testing in the manner to be described.

On turning our attention to a possible improvement in the method for the detection of the nickel, it was found that when the ammoniacal solution of the nickel ferricyanide was treated

* This Journal, xlviii, 67.

with strong sodium or potassium hydroxide solution, in the presence of an excess of potassium ferricyanide, a black flocky precipitate formed which gave no test for ferro or ferricyanide, and gave every indication of being nickelic hydroxide. This reaction we found to afford us a most delicate test for nickel.

The method as modified by us may be described as follows: Dissolve not more than 0·1 gm. of the salts of the two elements in about 5$^{cm^3}$ of water, add a few drops of a saturated solution of alum, destroy any free mineral acid by neutralizing with ammonium hydroxide, and make faintly acid with acetic acid. To this solution add about 0·5 grm. of potassium ferricyanide and agitate to effect the solution of the ferricyanide and the complete precipitation of the nickel and cobalt salts. Then add about 5$^{cm^3}$ of strong ammonium hydroxide and filter. To the filtrate, which should have no reddish color, add a piece of sodium or potassium hydroxide about the size of a pea and boil. The appearance of a black precipitate, in case of very small amounts of nickel showing first as a dark coloration, indicates nickel.

The tables following give a record of the experimental results. With the precautions indicated, this method may be applied very satisfactorily.

TABLE I.

	$CoSO_4 7H_2O$ grm.	$NiSO_4 \cdot 7H_2O$ grm.	$KAl(SO_4)_2$ saturated sol. cm^3	$K_3FeC_6N_6$ grm.	NH_4OH (conc.) cm^3	NaOH, solid, about size of a pea.	Result.
1.	----	0·0100	2	0·5	5·	"	Heavy ppt.
2.	----	0·0050	"	"	"	"	"
3.	----	0·0010	"	"	"	"	"
4.	----	0·0003	"	"	"	"	Distinct
5.	----	0·0001	"	"	"	"	Plain

TABLE II.

1.	0·10	----	"	"	"	"	None
2.	0·10	0·0100	"	"	"	"	Heavy
3.	0·10	0·0050	"	"	"	"	Distinct
4.	0·10	0·0030	"	"	"	"	Very faint
5.	0·05	----	"	"	"	"	None
6.	0·05	0·0100	"	"	"	"	Heavy
7.	0·05	0·0050	"	"	"	"	Distinct
8.	0·05	0·0030	"	"	"	"	Plain
9.	0·05	0·0010*	"	"	"	"	Faint

* Equivalent to 0·0002 of the metal.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Radio-activity of Uranium.*—Sir William Crookes has recently made an investigation in regard to Becquerel's rays, the most important result of which is the fact that he has succeeded in purifying uranium salts to such an extent that they are photographically inactive. There can be no doubt, therefore, that the radio-active rays are not a specific property of pure uranium, as has been previously supposed.

In the course of his experiments Crookes has tested a large number of specimens of barite and witherite from various localities without obtaining the slightest photographic action from them. He then tested every mineral in his extensive collection with the result that the following were found to be active: Pitchblende, uranite, autunite, orangite, thorite, euxenite, samarskite, alvite, bröggerite, monazite, xenotime, arrhenite, sipylite, fergusonite, chalcolite, hielmite. These minerals, which are arranged in the order of their intensity of action, all contain either uranium or thorium. Pitchblende, the most active mineral showed great variations in the activity of specimens from different localities, but roughly speaking the variation was proportional to the percentage of uranium present. A layer of powdered pitchblende a quarter of an inch in thickness gave as strong an action as one of the same material two inches thick, showing that the action does not pass through much thickness of the active material. The action was shown to be proportional to the time of exposure. Several salts and oxides of uranium were tested for their comparative activity upon the photographic plate with the result that they did not show much difference. A sample of metallic uranium from M. Moissan, however, showed a slighter action. With the intention of using it as a standard for comparison the author prepared a very pure specimen of uranium nitrate by treatment with ether and subsequent repeated crystallization. To his surprise this gave no action upon the sensitive plate. It was then shown by a series of experiments that no modification of physical or chemical conditions materially affects the radio-activity of a uranium compound when, to begin with, the salt experimented on possesses it; other similar experiments showed that, starting with an inactive uranium salt, nothing that can be done to it will cause it to acquire activity. It was found that when ordinary crystallized uranium nitrate is dissolved in ether a heavy aqueous liquid separates containing uranium nitrate that is much more active than that which remains dissolved in the ether. Systematic recrystallization from water showed a concentration of active material at the soluble end. Fractionation carried out by heating uranium nitrate until a certain amount of basic salt was produced, proved that the active body gradually

accumulated towards the basic end. By treating a solution of very active uranium nitrate with ammonium carbonate in excess, a small flocculent precipitate was obtained which showed great radio-activity ; it was found, however, that the active body was not wholly insoluble in ammonium carbonate. The precipitate just mentioned gave in five minutes as strong an action upon the sensitive plate as is given in 24 hours by ordinary uranium nitrate. The author calls the active substance provisionally "UrX." Thus far he has not observed any special spectrum for the substance. He decides that UrX is certainly distinct from "polonium," because the rays emanating from it penetrate glass while polonium rays do not. It is not so easy to settle whether UrX is distinct from radium, although many arguments point to its not being radium.

Experiments have been commenced by the author, which tend to show that thorium may be separated into an active and inactive body.

It is the author's opinion that in the present state of our knowledge of radio-active bodies it is safest to retain an open, or even a slightly sceptical mind. He calls attention to the fact that we recognize them mainly by photographic and electrical tests—reactions which give strong results even when the active body is present in too small a quantity to be detected by the spectrum—one of the most delicate of tests. He remarks that the radiographic test is cumulative. If no action is apparent at the end of an hour, one may be shown after twenty-four hours. If a day's exposure will show nothing, try a week's. The article concludes with the following sentence: "Considering my most active UrX does not contain sufficient of the real material to show in the spectrograph, yet is powerful enough to give a good impression on a photographic plate in five minutes, what must be its dilution in compounds which require an hour, a day, or a week to give an action?"—*Chem. News*, lxxxi, 253, 265. H. L. W.

2. *Electrical conductivity of Gases traversed by Cathode Rays.*—Starting from the results reached by J. J. Thomson and Rutherford in regard to the conductivity of gases traversed by Röntgen or uranium rays, owing to the production of positive and negative ions within them, J. C. McLennan shows that cathode rays impress a similar condition upon a gas. The conductivity produced by the cathode rays is explained as due to the motion of the ions, positive and negative, produced in the gas by the radiation. The ionization by cathode rays was found to be about 300 times that due to intense Röntgen radiation. On experimenting with different gases, the result was established that to determine the relative ionization produced in two gases by cathode rays of the same intensity it is sufficient to determine the absorbing power of the two gases for the same rays. It is also probably true that the ionizations produced by rays of constant intensity traversing different gases at the same pressure are proportional to the densities of the gases. The calculated

values expressing the relation between the ionization by cathode rays in different gases (oxygen, nitrogen, etc.) compared with that of air (= 1) was found to be approximately the same as those observed for Röntgen rays, except in the case of hydrogen. —*Proc. Roy. Soc.*, No. 431, p. 375.

3. *Kleiner Leitfaden der Praktischen Physik* von FRIEDRICH KOHLRAUSCH. Pp. xix, 260; 8vo. Leipzig, 1900 (B. G. Teubner). —The many excellent features of the work on Practical Physics by Dr. Kohlrausch, now before the public for some twenty-five years and in its eighth edition, are well known. The same author has now prepared an elementary volume on the same lines, which is designed especially for beginners in Physics and which has a unity character impossible in the larger work. His long experience has enabled him to write a book eminently fitted to fill the place for which it is designed; it is indeed a model both in arrangement and in clearness of statement and conciseness of presentation. It should have a wide sphere of usefulness not only at home, but wherever laboratory work in physics is carried on.

4. *Photometrical Measurements and Manual for the General Practice of Photometry with special reference to the Photometry of Arc and Incandescent Lamps;* by WILBUR M. STINE, Swarthmore College. Pp. vii, 270. New York, 1900 (The Macmillan Company).—The introduction of new forms of illumination in recent years has much increased the importance of photometrical measurements and extended the range of their application. Hence the value of the present volume, which gives in compact form the physical basis of photometry, the various forms of photometers, the light standards in use and finally the particular application of photometrical measurements to electric lamps of the two types. The author has not only brought together a remarkable amount of material within small compass, but in the frequent and well selected references has practically placed before the reader the important part of the original literature of the subject.

II. GEOLOGY AND MINERALOGY.

1. *Status of the Mesozoic Floras of the United States.* First Paper: *The Older Mesozoic;* by LESTER F. WARD, with the collaboration of Wm. M. Fontaine, Atreus Wanner, and F. H. Knowlton. From the Twentieth Annual Report of the U. S. Geological Survey, 1898–99, Part II, General Geology and Palaeontology, pp. 211–748, with 158 plates. Washington, 1900. —This extended and timely collaboration brings into convenient form for reference the principal known data concerning the Triassic and Jurassic floras of the United States, including many new descriptions. The salient facts dealt with are here enumerated.

The structural determination of several new genera and species

of conifers from Triassic and Jurassic horizons is by Dr. Knowlton. The new genus *Pinoxylon* may be specially mentioned as a Jurassic pine from South Dakota.

The Triassic flora of North Carolina, as based upon the original collection of Emmons and most of his types, is the work of Professor Fontaine. The Emmons collection of fossil plants made some fifty years since, and long supposed to have been lost, was recently found in the geological collection of Williams College by Professor T. Nelson Dale. Their redescription accompanied by new figures, and made in the light of a knowledge of the several other Triassic plant-bearing horizons since discovered in the United States, is especially satisfactory. The Triassic horizons of North Carolina being among the earliest investigated in this country, represent classic ground. Moreover, from the wooded character of the plant-bearing region, and from the fact that there are few natural products to induce excavation, specimens of this flora are now seldom to be obtained, save from a few localities principally in Chatham County, where, as at Egypt and Deep River, intermittent coal mining is still being carried on in the same horizons which yielded the important vertebrate fossils *Dromatherium*, and *Microconodon*, and also *Rhytidodon rostratus* Marsh. The Deep River locality was visited by the reviewer a few years since, but unfortunately the mines and culm heaps were on fire and could not be examined at that time, though being again put in order for further work.

A rich new Triassic flora from York County, Pennsylvania is of much interest. This was discovered by Mr. A. Wanner, and is in large part figured and described by him, Professor Fontaine also having determined the several forms. While some new plants occur, the essential agreement of this flora with that of North Carolina gives to its description a fundamental value.

A brief notice of the Triassic flora of Virginia, made by Fontaine the subject of Monograph VI of the U. S. Geological Survey publications, is given by Professor Ward, who notes the agreement between this and the Triassic flora of Lunz in Austria later studied by Stur and referred by him to the Keuper.

A characteristic Jurassic flora from Oroville, California, is described and illustrated by Professor Fontaine.

The Jurassic cycadean trunks from Carbon County, Wyoming, forming the new genus *Cycadella* with twenty species, are described by Professor Ward. A review of his preliminary description of these cycads was given by the present reviewer in this Journal for April, 1900, pp. 383–387, and need not be repeated here. The 104 plates now devoted to the illustration of these fine fossils forms the principal feature of the present volume, as well as a most interesting addition to the series of plates showing various forms of isolated cycadaceous leaves so prominent in the several Triassic and Jurassic floras mentioned above.

In addition to these Wyoming cycads Professor Ward also

describes as *Cycadeoidea nigra* a remarkably well preserved and handsome new species of cycadean trunk of supposed Jurassic age from the vicinity of Boulder, Colorado. This trunk is of more particular interest as extending the geographical range of the genus *Cycadeoidea* one step further west. While the distinctness of the present species is quite certain, it might be noted that externally it bears a strong resemblance to *Cycadeoidea Uhleri* from the Potomac formation of Maryland, the latter being in all probability a close specific, or even varietal relative. There is likewise a close resemblance to *Cycadeoidea* (Raumeria) *Masseiana* Capellini, from the scaly clays of Italy.

If in the present invaluable contribution there is anything open to criticism, it is perhaps the absence, in a work otherwise so profusely illustrated, of maps and sections of the more important localities and areas dealt with, such for instance as appear in the present author's contributions on the lower Cretaceous of the Black Hills in the XIXth Annual Report of the U. S. Geological Survey. G. R. W.

2. *La Flore Wealdienne de Bernissart;* par A. C. SEWARD. Memoires du Musée Royal d'Histoire Naturelle de Belgique, Vol. i, 1900.—The plants described in this memoir are the unfortunately somewhat fragmentary remains of the Flora occurring in the Wealden beds of Bernissart near the French frontier between Mons and Tournay, famous for the discovery in 1877 of numerous remarkably preserved Iguanodon skeletons.

The writer's conclusions are translated in part as follows: The plants of Bernissart are sufficient to demonstrate a closer resemblance to the Wealden facies than to any other Mesozoic type of vegetation.

I have elsewhere remarked that from the botanical point of view there exists an intimate resemblance between the Wealden type of Flora wherever well developed, as in England and Northern Germany, and the Flora of the inferior Oölite. There is not in fact a well marked break in the palaeobotanical continuity between the Jurassic and Wealden Floras of itself justifying the term Wealden as applied to plant beds such as those of Hastings on the coast of Sussex; comprised in the lower Wealden by the English geologists.

The composition of the flora of Bernissart is interesting for the marked preponderance of ferns, the apparently total absence of cycads, and the rarity of conifers. In other regions, for example in England, Portugal, and Germany the cycads play a preëminent role in Wealden vegetation. A collection containing many conifers and some ferns has recently been made in the Wealden strata at Bracquegnies, 30 kilomètres east of Bernissart, whilst specimens from Baume, 8 kilomètres further east, consist principally of conifers.

It is also remarkable that the specimens of *Weichselia Mantelli* and *Laccopteris Dunkeri* are more numerous in the Bernissart sediments than all others. Perhaps the deduction may be made

that the land drained by the rivers which laid down the plant debris in the Bernissart sediments was to a great extent covered by the two species first named and that the remaining vegetation also consisted principally of ferns. The aspect of the specimens and this abundance of ferns likewise suggests the idea that these plant-bearing sediments were derived from a low region chiefly occupied by ferns to the relative exclusion of larger plants or trees. These probably grew in the higher background or in the localities beyond the reach of the water which deposited the Bernissart strata. It is interesting, again, to note that the plant debris contained in these strata furnishes no facts favoring the presence of Angiospermous species. As we know from richer floras of the same age, it appears most probable that the higher classes of Phanerogams were not represented, or at least occupied a very secondary position in the vegetation of the Jurassic and Wealden periods. G. R. W.

3. *Notes on Some Jurassic Plants in the Manchester Museum;* by A. C. SEWARD, M.A., F.R.S., from Volume xliv, Part III of "Memoirs and Proceedings of the Manchester Literary and Philosophical Society, Session 1899–1900.—This communication deals with Inferior Oölite species from the Gristhorpe plant beds, in part figured by Lindley and Hutton. It adds certain important data to our knowledge of Jurassic vegetation. G. R. W.

4. "*The Maidenhair Tree*" (*Gingko biloba* L.); by A. C. SEWARD, F.R.S., and Miss J. Gowan, Newnham College. Cambridge, Annals of Botany, Vol. xiv, No. LIII, March 1900 (pp. 100–124, with plates viii–x.—This beautiful tree is here described with a completeness and precision which will be most pleasing and timely to every student of Botany or Palaeobotany.

Engler's subdivision *Gingkoaceæ* is adopted for the monotypic genus *Gingko*,—distinguished by the possession of motile male cells as well as by other characters of more or less importance. Following an historical sketch and diagnosis, the vegetative structures and fructification are described, reference always being had to the literature on the several subjects. A sketch of fossil *Gingkoaceæ* is appended, which adds greatly to the value of the contribution. G. R. W.

5. *New minerals from Greenland.*—A recently published account* of minerals collected in 1897 by G. FLINK in the Julianehaab district of southern Greenland, contains descriptions of a considerable number of new species and also of other rare known species associated with them. This important paper consists of two parts. Part I (pp. 7–180), by G. Flink, is on the minerals of Narsarsuk on the Tunugdliarfik fiord in southern Greenland. These are found only in a very limited area of the prevailing syenite, where the rock has in spots a pegmatitic character. The prominent minerals are microcline and ægirite, which often occur as large crystal individuals; in drusy cavities between these minerals the rarer species occur in successive generations. Of

*Meddelelser om Grönland, xxiv, 1899.

the more interesting known species of which full descriptions are given, may be mentioned the following: Parisite, eudidymite, epididymite, ægirite, arfvedsonite, catapleiite, neptunite, elpidite.

The new species described are nine in number. The descriptions of these leave nothing to be desired in the way of fullness and accuracy, but they can only be briefly characterized here.

CORDYLITE is a *barium-parisite*. It occurs in minute hexagonal crystals, club-like in form; they are related in angle to parisite; hardness 4·5; fracture conchoidal; sp. gravity 4·31; color wax-yellow. The composition is expressed by the formula $Ce_2F_2BaC_3O_8$.

ANCYLITE occurs in minute orthorhombic crystals with strongly curved faces. Color light yellow to orange or resin-brown; hardness 4·5; no cleavage; sp. gravity 3·95. In composition it is a hydrated carbonate of cerium and strontium for which the formula deduced is: $4Ce(OH)CO_3 + 3SrCO_3 + 3H_2O$.

SPODIOPHYLLITE resembles a chlorite; it occurs in crystals belonging to the rhombohedral system, combinations of the hexagonal prism and base; cleavage basal, micaceous; hardness about 3; sp. gravity 2·633; color ash- to pearl-gray. In composition it is a metasilicate related to ægirite; formula $(Fe,Al)_2(Mg,Fe,Mn)_3(Na_2,K_2)_2(SiO_3)_6$.

TAINIOLITE (Tæniolite) is a kind of mica occurring in elongated colorless crystals with sp. gravity = 2·86. An analysis by Mauzelius on 0·1 gram gave: SiO_2 52·2, Al_2O_3 2·7, FeO 0·6, MgO 19·1, K_2O 11·5, Na_2O 1·8, Li_2O 3·8, loss 8·7 = 100. The loss is referred to water (hydroxyl) and fluorine.

LORENZENITE occurs in needle-like orthorhombic crystals, colorless to violet or brown; luster adamantine; hardness 6; sp. gravity 3·42. An analysis (by Mauzelius) gave SiO_2 34·26, TiO_2 35·15, ZrO_2 11·92, Na_2O 17·12, K_2O 0·37, H_2O 0·77 = 99·59. The formula deduced is $Na_2(Ti,Zr)_2Si_2O_7$.

LEUCOSPHENITE occurs in wedge-shaped monoclinic crystals; color white inclining to grayish blue; luster vitreous, on some faces pearly; hardness 6·5; sp. gravity 3·05. An analysis (Mauzelius) gave: SiO_2 56·94, TiO_2 13·20, ZrO_2 3·50, BaO 13·75, Na_2O 11·14, K_2O 0·56, H_2O 0·31 = 99·40. The formula deduced is $Na_2Ba(TiO)_2(Si_2O_5)_3$. The mineral seems to be related to eudidymite.

NARSARSUKITE occurs in tabular tetragonal crystals; color honey-yellow to brownish gray; hardness a little above 7; sp. gravity 2·751. An analysis (Christensen) gave: SiO_2 61·63, TiO_2 14·00, Fe_2O_3 6·30, Al_2O_3 0·28, MnO 0·47, MgO 0·24, Na_2O 16·12, F 0·71, H_2O 0·29 = 100·04.

CHALCOLAMPRITE occurs in small regular octahedrons, resembling pyrochlore; color dark grayish brown inclining to red; hardness 5·5; sp. gravity 3·77. An analysis (Mauzelius) gave: Nb_2O_5 59·65, SiO_2 10·86, TiO_2 0·52, ZrO_2 5·71, Ce_2O_3 (etc) 3·41, Fe_2O_3 1·87, MnO 0·44, CaO 9·08, K_2O 0·38, Na_2O 3·99, H_2O 1·79, F 5·06 = 102·76 (deduct O) = 100·63. It is regarded as consisting of equal amounts of $RNb_2O_6F_2$ and $RSiO_3$.

ENDEIOLITE is related to the preceding species and like it occurs in regular octahedrons, at first taken for pyrochlore. Color dark chocolate-brown; hardness 5, sp. gravity 3·44. An analysis (Mauzelius) gave (assuming the loss to be SiO_2): Nb_2O_5 59·93, SiO_2 [11·48], TiO_2 0·76, ZrO_2 3·78, Ce_2O_3 4·43, Fe_2O_3 2·81, MnO 0·37, CaO 7·89, K_2O 0·43, Na_2O 3·58, H_2O 4·14, F 0·69 = 100·29 (deduct O) = 100. The formula deduced is $RNb_2O_6(HO)_2 + RSiO_3$.

Part II (pp. 181–213) contains descriptions of minerals from the nephelite-syenite of Julianehaab, by O. B. Boeggild and Chr. Winther. Three new species are included here and also an account of steenstrupite.

EPISTOLITE is a silver-white mineral described by Boeggild. It resembles brucite in its tabular crystals and pearly luster on the basal cleavage; it is, however, monoclinic in crystallization. Color white; hardness 1 to 1·5; sp. gravity 2·885. An analysis (Christensen) gave: SiO_2 27·59, Nb_2O_5 33·56, TiO_2 7·22, FeO 0·20, MnO 0·30, CaO 0·77, MgO 0·13, Na_2O 17·59, H_2O 11·01, F 1·98 = 100·35 (deduct O) = 99·52. No definite formula can be obtained, as the material used was somewhat altered.

BRITHOLITE, described by Winther, occurs in pseudo-hexagonal crystals, related in composite form to aragonite. Color brown, opaque; luster greasy to vitreous; hardness 5·5; sp. gravity 4·446. An analysis (Christensen) gave: SiO_2 16·77, P_2O_5 6·48 $(Ce,La,Di)_2O_3$ 60·54, Fe_2O_3 0·43, CaO 11·28, MgO 0·13, Na_2O 1·85, H_2O 1·27, F 1·33 = 100·08.

SCHIZOLITE, also described by Winther, is characterized as a manganese pectolite. It occurs in columnar masses and prismatic crystals, elongated parallel the *ab*-axis; cleavage parallel to two faces in this zone. Color pink to brown; hardness 5 to 5·5; sp. gravity 3·089. An analysis (Christensen) gave: SiO_2 51·06, TiO_2 0·68, Ce_2O_3 1·47, FeO 2·79, MnO 12·90, CaO 19·48, Na_2O 10·71, H_2O 1·36 = 100·45. The formula deduced is $4R_2^{I}O.10RO.15SiO_2$, which does not agree very closely with that of pectolite.

OBITUARY.

JAMES EDWARD KEELER. The Director of the Lick Observatory, Professor James E. Keeler, died at San Francisco after a brief illness on August 12th. Few of his friends had a suspicion that his health was otherwise than in the excellent condition which was believed characteristic, until the widely published announcement of his death met their eyes.

James Edward Keeler, born at La Salle, Illinois, on September 8th, 1857, where he also received his early schooling, doubtless owed much of his intellectual alertness to his father whose career had been singularly varied and interesting. A paymaster in the navy during the civil war, his intimate connection with the monitor class of ironclads, including a participation in the famous fight between the Monitor and the Merrimac and subsequent

experience in the East, strengthened in him the innate taste for mechanical arts which he shared and enjoyed with his distinguished son. The removal of the family to Mayport, Florida, while the future astronomer was still quite young, profoundly modified his course of development in replacing an ordinary career of schooling by an employment of all his energies in adapting himself to a new life and a new environment. But even in this active life his natural inclination towards astronomy asserted itself. By the exercise of much self-denial he was able to purchase an achromatic telescope objective of about two and a half inches diameter; this he mounted and supplied with a thoroughly serviceable stand, and with the product of his ingenuity he commenced the acquiring of his remarkable store of knowledge of physical astronomy. This was followed by a singular consequence. Mr. Charles H. Rockwell, who has ever remained a kind and sympathetic friend, learned by accident of the young astronomer in Florida and, eager to advance scientific learning in every way, secured for him an opportunity to gain the advantages afforded by one of our greater universities. As Mr. Keeler's schooling was not of a character which fitted him immediately for entrance to university standing, he entered as a special student in the Johns Hopkins University, then in the initial stages of its evolution. Here it was that the writer became intimate with him and learned his extraordinary capacity for fruitful work. Shortly after securing his bachelor's degree here in 1881, he became an assistant to Professor Langley, aiding him most efficiently in his delicate researches with the bolometer, at the same time establishing a reputation for scientific ability which practically secured his future. With this experience, broadened by two years of study at Berlin and Heidelberg and further increased by four or five years passed at Mt. Hamilton as an astronomer of the Lick Observatory, his subsequent career is wholly natural. In 1891 he accepted the position as Director of the Allegheny Observatory, a position exceptionally congenial to him because of the many friends gained during the time in which he acted as assistant to his predecessor Professor Langley. The opportunity for more important work, however, which came to him in 1898, with an invitation to become Director of the Lick Observatory, obliged him to sacrifice this agreeable environment and to enter upon a life of great fruitfulness and activity which has been, so unfortunately for science, interrupted by his death.

This brief note does not offer the place to review the scientific achievements of Mr. Keeler; but it is gratifying to find that not only those engaged in allied branches of science recognized his merits, but more popular appreciation was evinced by his election as an Associate of the Royal Astronomical Society in 1898, and as a member of the National Academy at its last meeting. Quite fitting is it, however, that the writer should take this occasion to record the grief of a great number of his personal friends through whom his life was enriched in a degree never attained by men less selfish and less loyal than he. C. S. H.

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Yale University Museum, New Haven, Conn.

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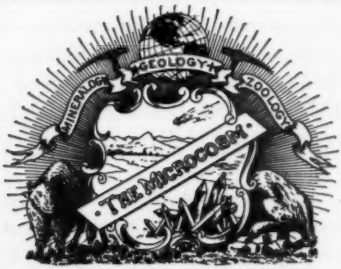

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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci. Vol. 1. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892.

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